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NOVICHOK(S): A CHALLENGE TO THE CHEMICAL WEAPONS CONVENTION

NOVICHOK(S): UM DESAFIO À CONVENÇÃO PARA A PROIBIÇÃO DE ARMAS QUÍMICAS

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Abstract

Chemical weapons have been a part of human history for many centuries. However, the pinnacle of their production, development and use was in the 20th century, as new technological and scientific discoveries were made. The disarmament, non-proliferation and verification measures implemented due to the entry into force of the Chemical Weapons Convention in the 1990s kept the threat somewhat under control. However, in the 21st century, the world witnessed several poisonings using "novel" chemical compounds commonly known as '*Novichok(s)*'. While the world may be aware that these chemical compounds exist, their history and properties are uncertain due to the secrecy of their development and weaponization programmes. The use of these agents led to the first amendment to the Chemical Weapons Convention, 22 years after it entered into force, to add them to the Convention's verification lists. The events in which these agents were used confirm the need to keep chemical weapons under strict control. This can be achieved by a continuous and thorough implementation of the Chemical Weapons Convention, a robust, broad and versatile treaty.

Keywords: Novichok(s), Chemical Weapons, Chemical Weapons Convention.

Resumo

As armas químicas acompanham a História da Humanidade desde há muitos séculos. Contudo, o auge da sua produção, desenvolvimento e utilização foi no século XX, quando a capacidade tecnológica e o conhecimento científico assim o permitiram. A entrada em vigor da Convenção para a Proibição de Armas Químicas, nos anos 90, trouxe consigo medidas de desarmamento, não-proliferação e verificação que, de certa forma, controlaram esta ameaça.

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Todavia, no século XXI, o mundo assistiu a vários envenenamentos com recurso a compostos químicos "novos", designados genericamente por "Novichok(s)". Apesar da sua existência ser conhecida, a história e informação acerca destes compostos químicos está envolta em incerteza, dado o secretismo associado ao programa de desenvolvimento e produção das respetivas armas. O seu emprego levou, pela primeira vez na história, à atualização da Convenção, 22 anos depois da sua entrada em vigor, através da inclusão destes compostos nas listas de verificação. Os eventos associados com esta classe de agentes vieram reafirmar a necessidade de manter o controlo sobre as armas químicas, conseguido através da robustez, amplitude e versatilidade da Convenção para a Proibição de Armas Químicas.

Palavras-chave: *Novichok(s), Armas Químicas, Convenção para a Proibição de Armas Químicas.*

1. Introduction

The Civil Protection duties of the Portuguese Armed Forces are set out in several official documents, including the Constitution of the Portuguese Republic (CRP) (Constitutional Law No. 1/2005, of 12 August), the Law on National Defence and the Basic Law on Civil Protection. Pursuant to no. 6 of Article 275 of the CRP (Constitutional Law No. 1/2005), the Armed Forces "[...] may be charged, as laid down by law, with cooperating in civil defence missions [...]". One of the areas in which the Armed Forces are expected to intervene is CBRN – Chemical, Biological, Radiological and Nuclear. The Strategic Concept on National Defence (CEDN) (Council of Ministers Resolution No. 19/2013, of 5 April) states that the State should "develop the military capabilities required to mitigate the consequences of [...] CBRN attacks [...]" and that "[...] enhancing the national response capacity to respond to health risks is a priority, [...] in order to respond more quickly and effectively to [...] attacks with CBRN weapons".

Therefore, to address these threats, CBRN experts should have up-to-date technical and scientific information. Recent examples of use of chemical weapons (CW), such as in Syria, or in the assassination of Kim Jong-Nam (half-brother of North Korean leader Kim Jong-Un) using a nerve agent, and of the use of a novel class of chemical agents in the United Kingdom (UK) and Russia in 2018 and 2020, respectively, show that despite the Chemical Weapons Convention (CWC) has been almost globally implemented, the chemical threat is still very much present.

This article addresses the topic of "*Novichok(s)*" because, as recent events have shown, their use is a current, serious and relevant threat that has posed new technical, scientific, political and diplomatic challenges over recent years. This work was carried out by reviewing the literature on the topic. In addition to this Introduction and the Final Reflections, the article is organized in three chapters: i) Historical background: from Antiquity to the Chemical Weapons Convention; ii) the Chemical Weapons Convention; and iii) *Novichok(s)*.

The first chapter addresses the history of CW and describes their use and evolution over time. The second chapter examines the CWC, from the discussion phase to the drafting of the Convention, its content, the international organization that enforces it and the Portuguese authority that verifies and coordinates its compliance in Portugal. These first two chapters introduce the topic of CW and the international laws that regulate them, and provide a background to Chapter 3. This last chapter on *"Novichok(s)"* describes how these agents were developed and produced, the events in which they have been used, and their impact on the amendment to the CWC.

2. Historical background: from Antiquity to the Chemical Weapons Convention

Chemical compounds and biological agents have been employed in warfare since ancient times, and literary and archaeological records of their use have been found dating back thousands of years (Mayor, 2018). Sulphur oxides produced by the combustion of tar and sulphur were used during the siege of the Persian city of Dura Europos (present day Syria) in 256 BC. This is the first recorded case in which a chemical substance was used as a weapon due to its toxicity, but the flammable properties of chemicals have been exploited for warfare purposes for even longer (Vilches, Alburquerque & Ramirez-Tagle 2016).

In fact, chemical compounds have been used in armed conflicts throughout the history of warfare. In the 17th century, explosive munitions containing alkaloids extracted from the belladonna plant (*Atropa belladonna*) were used during the Siege of Groningen (1672, French-Dutch War). In response to these events, the Strasbourg Agreement, considered the first international treaty on chemical warfare, was signed on 27 August 1675, prohibiting the use of "perfidious and odious" toxic devices. In the years that followed, other agreements on chemical warfare and related issues were established (Table 1), such as the Brussels Declaration (1874) and the Hague Conventions of 1899 and 1907. Another series of conferences at The Hague were planned for 1914, which did not take place due to the start of World War I (WWI).

It was during WWI that new scientific and technological discoveries in the chemical industry allowed chemical compounds to be used as CW of mass destruction. Tear gas had already been used in small-scale attacks in 1914 (Fitzgerald, 2008; Vilches et al, 2016), as well in a more significant attack in January 1915, which was unsuccessful because the tear gas did not vaporise due to the cold weather (Sidell, Takafuji, & Franz, 1997). On 22 April 1915, during the Battle of Ypres, German troops released chlorine gas, a choking agent (Table 2), in what is considered the first large-scale attack with a CW, causing approximately 5000 deaths and 15200 casualties among both German and Allied forces (Van der Kloot, 2004).

Table 1 – International agreements regulating the use of chemical agents in warfare

Agreement	*established during the*	*which*	*in*
Strasbourg Agreement		bans the use of "perfidous and odious" toxic devices	Strasbourg, 1675
Project of an International Declaration concerning the Laws and Customs of War (known as the **Brussels Declaration**)	Brussels Conference	bans the "employment of poison or poisoned weapons" and "the employment of arms, projectiles or material calculated to cause unnecessary suffering"	Brussels, 1874
Declaration Banning the Use in Warfare of Projectiles that Diffuse Asphyxiating or Deleterious Gases (known as the **1899 Hague Convention**)	International Peace Conference	declares that "Contracting Powers agree to abstain from the use of projectiles the sole object of which is the diffusion of asphyxiating or deleterious gases"	The Hague, 1899
Convention (IV) respecting the Laws and Customs of War on Land and its Annex (known as the **1907 Hague Convention**)	International Peace Conference	bans the employment "of poison or poisoned weapons" and the employment "of arms, projectiles or material calculated to cause unnecessary suffering"	The Hague, 1907
Protocol for the Prohibition of the Use of Asphyxiating, Poisonous or Other Gases, and of Bacterological Methods of Warfare (known as the **1925 Geneva Protocol**)	Conference for the supervision of the international trade in arms and ammunition	bans the use of "asphyxiating, poisonous or other gases" and "of bacteriological methods of warfare"	Geneva, 1925
Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction (known as the **Chemical Weapons Convention**)	Conference on Disarmament	bans the development, production, stockpiling and use of chemical weapons and requires their destruction within a specified period of time	Geneva, 1992; signed in Paris, 1993
United Nations Security Council **Resolution 1540**	4956th United Nations Security Council Meeting	sets out, among other obligations, that "States Parties refrain from providing any form of support to non-State actors that attempt to develop, acquire, manufacture, possess, transport, transfer or use nuclear, chemical or biological weapons and their means of delivery"	New York, 2004

Once it became clear that this type of weapon was highly effective, belligerent forces began investing in programmes to develop chemical warfare agents (CWA)[1] and significant resources and capabilities were committed to research, develop, produce, store and use CW during WWI. The CWA most widely used in the war were phosgene, diphosgene, hydrogen cyanide and cyanogen chloride (Table 2). In July 1917, about two years after chlorine gas was first used, it was again at Ypres that the German forces brought a new and more harmful CWA to the conflict: sulphur mustard, also known as mustard gas[2] or yperite. Unlike the gases that had been used until then, which affected the respiratory system (choking agents) and cellular respiration (blood agents), sulphur mustard was a vesicant or blister agent (Table 2) that produced blisters / vesicles when it came into contact with the skin and temporary blindness if it touched the eyes, which could develop into permanent eye damage in cases

[1] In addition to investing in weapons development programmes, which involved synthesising CWA and producing CW, countries also invested in defensive research to counter the new threat, e.g. gas masks and medical countermeasures.
[2] Even though there are other types of mustard agents, such as nitrogen mustard and sesquimustard, the term mustard gas is commonly used to refer to sulphur mustard, which is actually a liquid at room temperature.

of severe exposure. Sulphur mustard was used so effectively in WWI it became known as the "King of Gases", as it caused more casualties than all other gases combined (Fitzgerald, 2008; Silva Borges Jr., Figueroa-Villar & de Castro, 2012). By the time the war ended, the use of 21 different chemical compounds (Tucker, 2006) had resulted in 1.3 million casualties and 90 000-100 000 deaths (Fitzgerald, 2008; Silva et al., 2012; Tucker, 2006; Vilches et al., 2016).

Table 2 – Characteristics of the most commonly used chemical warfare agents

Classes and Agents	*Persistence*	*Absorption route*	*Effect*	*Dispersion method*
Chocking agents Chlorine (Cl) Phosgene (CG) Disphosgene (DP) Chloropicrin (PS)	Low	Lungs	Accumulation of fluid in the lungs, resulting in asphyxia/hypoxia	Gas
Blister Agents Sulphur mustard (HD) Nitrogen mustard (HN) Phosgene oxime (CX) Lewisites (L)	Very high High Low High	Lungs and skin (main route of absorption)	Damages the skin (blister agent), eyes and respiratory tract	Liquid, aerosol, vapour and dust
Blood agents Hydrogen cyanide (AC) Arsine (SA) Cyanogen chloride (CK)	Low	Lungs	Interferes with the cellular respiration process, resulting in asphyxia/hypoxia	Gas
Nerve agents *Series G:* Tabun (GA) Sarin (GB) Soman (GD) *Series V:* VX *Series A:* A-230, A-232, A-234, etc.	 Low Low Moderate Very high Moderate	Lungs (main route of absorption) and skin	Over stimulates the nervous system, resulting in muscle paralysis and respiratory distress	Liquid, aerosol, vapour and dust

During WWI, the harmful effects of CW had become clear and there were several attempts to limit or ban the use of this type of weapon. One attempt garnered the most support from the international community, and the agreement known as the 1925 Geneva Protocol was signed on 17 June 1925 by 38 States, including Portugal (Decree No. 17 246, of 20 August 1930). Despite these treaties, CW continued to be used during the years between the wars, such as when Italy used sulphur mustard and arsine against Ethiopian soldiers and civilians in 1936, during the Second Italo-Ethiopian War (Sbacchi, 2005).

Despite the fact that the international community condemned the use of CW because it considered its effects cruel and inhumane, the military potential of these types of weapons meant that several nations continued to invest in the development of new and more toxic CWA. The heyday of this research was in the 1930s, with the development of new vesicant agents such as nitrogen mustards, *o*-mustard and various mixtures of these compounds. Nerve agents were also synthesised for the first time (Ganesan, Raza &Vijayaraghavan, 2010; Pitschmann, 2014; Tucker, 2006). In 1936, when German chemist Gerhard Schrader was developing new insecticidal compounds for Bayer AG (one of six companies in the German IG Farben consortium of chemical industries), he synthesised a highly toxic organophosphorus compound that acted on the central nervous system (Black, 2016; Tucker, 2006). Because it was significantly more toxic to mammals than to insects, it was not approved for use as an insecticide. However, the German military was interested in the compound for exactly the same reason. Due to its potential as CWA, a research project was created to further develop Tabun, the name by which the compound became known (Sidell et al., 1997; Silva et al., 2012). In 1938, Schrader and his colleagues developed Sarin, a compound similar to Tabun but five times more potent than its predecessor (Sidell et al., 1997).

CW were used 1312 times by Japanese forces in ten battles of the Second Sino-Japanese War (1937-1945). According to the charges filed by China at the League of Nations, these CW contained sulphur mustard, phosgene and tear gas (Guillemin, 2017). These events disprove the widespread belief that CW were not used during World War II (WWII), which is based on the fact is that these types of weapons were not employed on European battlefields[3].

Several countries invested in the production and storage of this type of weapons during WWII. Germany, especially, never stopped researching and developing neurotoxic compounds during the war, and in 1944, Richard Kuhn synthesised Soman (Sidell et al., 1997; Silva et al., 2012). This group of compounds became known as "G-series". The most common explanation for the term is that the "G" refers to the compounds having been developed in Germany (Figure 1).

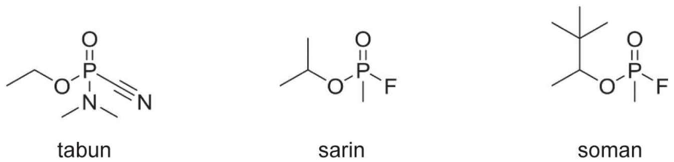

Figure 1 – G-series nerve agents
Source: Adapted from Nepovimova and Kuca (2018).

After WWII, with the capture of several production facilities and considerable efforts from intelligence services, the Allies discovered the German CW and CWA development and production programme. As a result, in the years after the war, the United States of America (US), the UK and the Soviet Union, as well as other countries (on a smaller scale) invested in CW development and production programmes. Interestingly, history repeated itself in 1952, as the UK discovered amiton, a new organophosphate compound with low volatility, while researching new types of insecticides. As the compound was highly toxic for humans, the British government wanted to explore its potential as a CWA and tasked the scientists at the Porton Down laboratories with developing this second generation of neurotoxic compounds, the V-series (Figure 2), said to be named after the English word "venomous" (Black, 2016; Sidell et al., 1997). The most relevant compound in the V series is called VX (the Russian and Chinese analogues are known as RVX and CVX, respectively). Due to its low volatility (and therefore high persistence), extremely high toxicity and stability in storage, several countries began producing it in large quantities (Black, 2016; Ganesan et al., 2010; Silva et al., 2012).

[3] Although CW were not used in the European theatres of operations, millions of people were killed in the gas chambers of German concentration camps using Zyklon B, a pesticide that contained hydrogen cyanide.

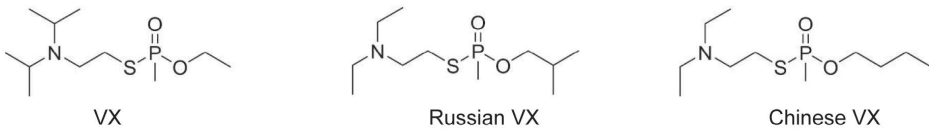

Figure 2 – V-series nerve agents
Source: Adapted from Nepovimova and Kuca (2018).

Since the 1950s, several studies have been conducted in the US and the UK to examine the effects of exposure to CWA, in which military volunteers were exposed to non-lethal amounts of vesicant (e.g. sulphur mustard) and neurotoxic (e.g. sarin) agents (Bullman & Kang, 2000; Keegan et al., 2007; Page, 2003; Pechura & Rall, 1993). Other trials using chemical compounds were conducted to assess the dispersion of biological agents, including a trial using the fluorescent pigment zinc cadmium sulfide as a simulant (Elliott, Phillips, Clayton & Lachmann, 2002; National Research Council, 1997).

In the 1980s, the world again witnessed the harrowing effects of CW[4] when Iraq used blister and nerve agents against Iranian soldiers and civilians during the Iran-Iraq war. The Iraqi forces also used these compounds against their own population, and particularly against Kurdish civilians, during an attack in Halabja in 1988 that caused 3000-5000 deaths from exposure to sulphur mustard and sarin (Black, 2016; Ganesan et al., 2010).

In 1994 and 1995, after the CWC had already been approved and signed by 156 countries (OPCW, 2018a) [see chapter *3. Chemical Weapons Convention*], members of Japanese cult Aum Shinrikyo carried out two terrorist attacks using the nerve agent sarin. In the first case, the group's attempt to assassinate three judges (who survived the attack) in a residential area of the city of Matsumoto resulted in seven deaths and over 200 casualties (Black, 2016; Silva et al., 2012). However, the 20 March 1995 attack on the Tokyo metro system was on an entirely different scale – it is estimated that 20 kg of sarin were released by puncturing plastic bags containing this agent (Black, 2016). The attack resulted in 12 deaths and had serious consequences for the healthcare system, as over 5000 victims had to be examined and treated in hospitals. The low number of deaths was mainly due to impurities in the sarin produced by the cult members and the inefficiency of the release system (Black, 2016; Ganesan et al., 2010).

3. Chemical Weapons Convention

In the wake of WWII, the world lived under the shadow of an impending nuclear conflict and CW fell off the public agenda. It was only in 1968, at the United Nations (UN) Disarmament Conference in Geneva, that chemical and biological weapons were discussed again. In 1972, as new biological weapons were being developed at rapid rate, the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin

[4] CWA and other chemical compounds were used on a smaller scale in previous decades, for example, when US forces used irritant agents (CS) and defoliant herbicides (Agent Orange) in the Vietnam War, or when Egypt allegedly used sulphur mustard and phosgene in the civil war in North Yemen. Moreover, there may be other classified cases of CWA use that have not yet been disclosed to the public.

Weapons[5] and on their Destruction (BTWC) was adopted and opened for signature. Pursuant to Article IX of the BTWC, signatory States to the BTWC agreed to continue negotiations on CW:

> Each State Party to this Convention affirms the recognized objective of effective prohibition of chemical weapons and, to this end, undertakes to continue negotiations in good faith with a view to reaching early agreement on effective measures for the prohibition of their development, production and stockpiling and for their destruction, and on appropriate measures concerning equipment and means of delivery specifically designed for the production or use of chemical agents for weapons purposes. (Decree No. 208/73, of 8 May)

However, the negotiations on CW took much longer, and an *ad hoc* working group on chemical weapons was established at the 1980 Disarmament Conference. During the 1980s, other events that boosted the efforts to develop the CWC included the attack on Halabja, the constant threat of chemical warfare during the Gulf War, and the improvement of relations between the world's superpowers, with the signing of a bilateral agreement between the US and the Soviet Union, in which they agreed to destroy their chemical arsenals and refrain from producing CW (OPCW, 2014).

The CWC was formally adopted at the 1992 Conference on Disarmament, and was opened for signature in 1993 in Paris. During the three days of the conference, the document was signed by 130 countries, including Portugal. This adherence to an arms control treaty was unprecedented. The Convention provided that it would enter into force at least two years after the date of its signature and 180 days after its ratification by the 65th State Party. This gave the Preparatory Commission time to carry out the work required to establish an organization capable of implementing the CWC (OPCW, 2014).

The Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction, the formal title of the CWC, entered into force on 29 April 1997. The Organisation for the Prohibition of Chemical Weapons (OPCW), the implementing body for the CWC [see subchapter *3.2. Organization for the Prohibition of Chemical Weapons*], met for the first time on 6 May 1997 at the First Conference of States Parties, which was attended by representatives from all countries that signed the Convention.

3.1. CWC articles and schedules

The CWC consists of a Preamble, 24 Articles and three Annexes, and is translated into the six official languages of the OPCW[6]. Table 3 provides a brief explanation of the contents of each Article of the CWC.

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[5] The official translation of the treaty into Portuguese was published in the Journal of the Republic I, No. 108 (1973). However, the word 'Toxin' in the original English title of the treaty should have been translated as '*Toxinas*' or '*Toxínicas*', rather than as '*Tóxicas*', in the Portuguese version of the document (*Convenção sobre a Proibição do Desenvolvimento, da Produção e do Armazenamento das Armas Bacteriológicas (Biológicas) ou Tóxicas*). This means that the Portuguese title is inaccurate because it does not describe the topic it addresses: biological weapons and toxins, which are highly toxic chemical compounds produced by biological organisms, e.g. plants or micro-organisms.

[6] Many countries have translated the CWC into their official language(s) to facilitate the dissemination and implementation of the Convention. The English version of the CWC (and its official translation into Portuguese) was published in Journal of the Republic I-A, No. 169, 1st supplement, of 23/07/1996 (Portuguese Parliament Resolution No. 25-A/96). A Portuguese-only version of the CWC is available on the website of the National Authority for the Prohibition of Chemical Weapons (Translator's note: for the sake of accuracy, the contents of Table 3 were taken directly from the English version of the CWC, rather than back-translated from the Portuguese version).

Table 3 – Brief overview of the articles of the Chemical Weapons Convention

Article	Contents
I – General obligations	sets out the general obligations of each State Party under the Convention
II – Definitions and criteria	lists the definitions and criteria to be used in implementing the Convention (e.g. the definition of "chemical weapon" or "precursor")
III – Declarations	requires each State Party to submit declarations to the OPCW within 30 days after the Convention enters into force for that State Party (e.g. declare whether it owns CW or whether there are CW production facilities in its territory)
IV – Chemical weapons	sets out the requirements for States Parties to destroy their CW
V – Chemical weapons production facilities	sets out the requirements for States Parties to destroy and / or convert their CW production facilities
VI – Activities not prohibited under this Convention	covers activities that are not prohibited under the CWC, also known as non-proliferation measures or the industry verification regime
VII – National implementation measures	describes the national implementation of the Convention by State Parties and requires each State Party to enact implementing legislation
VIII – The Organization	establishes the OPCW as the implementing body of the Convention, its composition and organs
IX – Consultations, cooperation and fact-finding	provides for the consultation and clarification of facts if there are concerns about possible non-compliance
X – Assistance and protection against chemical weapons	provides for assistance and protection to a State Party that has been attacked or threatened with attack by CW
XI – Economic and technological development	deals with international cooperation for the economic and technological development of States Parties
XII – Measures to redress a situation and to ensure compliance, including sanctions	deals with the measures that must be taken to ensure compliance with the Convention, including sanctions against a State Party that fails to uphold its treaty obligations
XIII – Relation to other international agreements	states that nothing set out in the CWC in any way limits or detracts from the obligations assumed by States Parties under other international treaties
XIV – Settlement of disputes	concerns the settlement of disputes that may arise concerning the application or the interpretation of the Convention
XV – Amendments	deals with possible amendments to the Convention
XVI – Duration and withdrawal	deals with the duration of the Convention and the States Parties' right to withdraw from it
XVII – Legal status of the annexes	describes the status of the annexes as integral parts of the Convention
XVIII – Signature	deals with the procedure for signature of the Convention
XIX – Ratification	deals with the procedure to ratify the Convention
XX – Accession	deals with the procedure to the accession to the Convention
XXI – Entry into force	deals with the entry into force of the Convention
XXII – Reservations	declares that there cannot be reservations incompatible with the articles of the Convention
XXIII – Depositary	sets out the Depositary of the Convention and respective responsibilities
XXIV – Authentic texts	deals with the authenticity of the texts in other languages

Source: Adapted from ANPAQ (n.d.a) and OPCW (n.d.).

The objectives of the CWC are clearly defined in its Article I.1, in which States Parties agree to never, under any circumstances:

- Develop, produce, otherwise acquire, stockpile, transfer or retain CW;
- Use CW;

- Engage in any military preparations to use CW;
- Assist, encourage or induce anyone to engage in any activity prohibited under the CWC.

As defined in Art. II.1, ***chemical weapons*** means, together or separately:

> (a) Toxic chemicals and their precursors, except where intended for purposes not prohibited under this Convention, as long as the types and quantities are consistent with such purposes;
> (b) Munitions and devices, specifically designed to cause death or other harm through the toxic properties of those toxic chemicals specified in subparagraph (a), which would be released as a result of the employment of such munitions and devices;
> (c) Any equipment specifically designed for use directly in connection with the employment of munitions and devices specified in subparagraph (b). (OPCW, n.d.)

The *Annex on Chemicals* contains the criteria for the inclusion of toxic chemicals or precursors in Schedules 1, 2 and 3, based on their risk and on the quantities of chemicals that are produced for commercial purposes. The Annex also includes the Schedules:

- Schedule 1 contains compounds that pose a "high risk" to the purpose of the CWC, whether they are toxic chemicals or their precursors. The compounds on this list have no commercial / industrial use, and several have been used as CWA (e.g. Sarin);
- Schedule 2 includes compounds that pose a "significant risk" to the purpose of the CWC, such as products which may be used as CWA (e.g. amiton), their precursors and precursors to Schedule 1 compounds. While these compounds may be used for purposes not prohibited by the CWC, they are not produced in large quantities;
- Schedule 3 includes compounds that may pose a risk to the purpose of the CWC because they may be produced in large quantities for purposes not prohibited under the Convention. These substances or their precursors can be used as CWA, and some already have (e.g. phosgene).

In addition to purposes stated above, States Parties also undertake to destroy:

- The CW they own or possess, or that are located in any place under their jurisdiction or control (Art. I.2);
- CW that they have abandoned on the territory of another State Party (Art. I.3);
- The CW production facilities they own or possess, or that are located in any place under its jurisdiction or control (art. I.4).

The CWC includes a verification regime to ensure that States Parties destroy their CW and CW production facilities, as well as to verify the annual declarations regarding the compounds included in Schedules 1, 2 and 3 (Art. IV to VI). This verification regime consists of regular inspections, which are described in the *Verification Annex*. The Annex also describes two other types of inspections: challenge inspections in case of suspicion of non-compliance with the CWC (Art. IX); and investigations in cases of alleged use of CW (Articles IX and X).

Finally, the *Confidentiality Annex* aims to ensure the security of materials and documentation submitted / declared to the OPCW, such as classified documents of a State Party or business information belonging to companies / industries under inspection.

3.2. Organization for the Prohibition of Chemical Weapons

As the implementing body of the Convention, the OPCW oversees the international efforts to permanently eliminate all CW. As set out in the CWC, the OPCW consists of three organs: the Conference of the States Parties, the Executive Council, and the Technical Secretariat.

As the principal organ of the OPCW, the *Conference of the States Parties* oversees the implementation of the Convention and decides the organization's strategic direction. It is a plenary body composed of representatives from all States Parties of the OPCW that meets in sessions held annually at the OPCW Headquarters in The Hague. Some of its main functions are:

- To examine the necessary measures to ensure compliance with the provisions of the CWC;
- To review and approve the organization's report, programme and budget;
- To elect the members of the Executive Council;
- To appoint the Director-General;
- To foster international cooperation in the field of chemical activities for peaceful purposes;
- To review scientific and technological developments that may affect the implementation of the Convention.

The *Executive Council* is the executive organ responsible for the effective implementation of the CWC. It consists of 41 Member States appointed by the Conference of States Parties, in a system of rotation. Its main functions are:

- To prepare the organisation's draft report, programme and budget;
- To prepare the report on the Executive Council's activities;
- To make a recommendation for the position of Director-General;
- To make recommendations to the Conference regarding measures to be taken in cases of non-compliance with the Convention by a State Party;
- To conclude agreements on behalf of the Organization;
- To approve agreements relating to verification activities negotiated by the Technical Secretariat.

The *Technical Secretariat* assists the Conference of States Parties and the Executive Council in administrative and technical matters and implements the measures taken by these organs. Some of its main tasks are:

- To prepare the draft programme, budget and annual report on the implementation of the Convention;
- To carry out the verification measures set out in the CWC, including inspections;
- To provide technical support to States Parties in the implementation of the provisions of the Convention;
- To assist States Parties in the development of programmes to protect against CW.

3.3. National Authority for the Prohibition of Chemical Weapons

Pursuant to Article VII.4 of the CWC:

> In order to fulfil its obligations under this Convention, each State Party shall designate or establish a National Authority to serve as the national focal point for effective liaison with the Organization and other States Parties. (OPCW, n.d.)

The Portuguese National Authority for the Prohibition of Chemical Weapons (ANPAQ) was established, and its mandate and operating regulations are set out in Law No. 66/2007 of 28 November and Decision No. 5300/2010 of 24 March, respectively.

The ANPAQ is the Portuguese State's liaison to the OPCW and other States Parties that adhered to the CWC, and acts as an interlocutor for the Portuguese entities, both public and private, whose activities / products are covered by the Convention. Its main tasks are:

- To coordinate all activities carried out to implement the CWC in Portugal;
- To promote measures required to verify and oversee compliance with the Convention;
- To organize and follow up on OPCW inspections to national industrial complexes, and to assess the findings of these inspections;
- To define the composition of the National Escort Team;
- To issue an opinion regarding the acceptance of international inspectors;
- To provide guidance on how the programmes of assistance and protection against chemical weapons will be implemented;
- To help define Portugal's positions within the OPCW;
- To prepare and deliver the national declarations required by the Convention to the OPCW. (ANPAQ, n.d.b)

The ANPAQ is headed by a high-ranking official from the Ministry of Foreign Affairs, and its members are representatives of the Ministries of: National Defence, Finance, Internal Administration, Economy, Science, Health and Intelligence Services. The Technical Secretariat of the National Authority (STAN) is staffed by experts in various areas and provides technical and scientific support to the ANPAQ.

4. *Novichok(s)*

The discovery of V-series nerve agents was the result of the investment in CWA development and CW production programmes in the post-WWII era. While the British developed VX, and shared the production technology with the US in a bilateral agreement (Nepovimova & Kuca, 2018), the Russians developed their own version, RVX. Over the next decades, these countries' scientists continued to advance the field and, in 1971, the *Foliant* programme was approved by the Central Committee of the Communist Party of the Soviet Union and the Council of Ministers of the USSR (Torres & Colasso, 2018; Tucker, 2006). The programme aimed to develop new CWA that should be, according to Kloske and Witkiewicz (2019) and Nepovimova and Kuca (2018):

- Undetectable by the detection instruments available to NATO member states at the time;
- More toxic than V-series agents;
- Able to penetrate the body of enemy combatants, even when wearing protective equipment;
- Safer to store and prepare than previous CWA.

The project was headed by Dr Pyotr Petrovich Kirpichev of the State Scientific Research Institute for Organic Chemistry and Technology, better known by its acronym in Latinised Russian "GosNIIOKhT", or ГосНИИОХТ in Cyrillic (Tucker, 2006).

In October 1991, an article titled "Inversion" was published in Moscow newspaper *Kuranty*, in which Vil Mirzayanov, a Russian scientist who worked at GosNIIOKhT for 26 years (now exiled in the US), stated that the USSR was still secretly developing a new class of highly potent neurotoxic agents (Tucker, 2006). However, perhaps because of the political turmoil that triggered the dissolution of the Soviet Union, the Russian scientist's revelations did not have much impact.

The following year, Dr Mirzayanov and Russian chemist Lew Fiodorov co-authored a new article – titled *"A Poisoned Policy"* – for the weekly newspaper *Moskovskiye Novosti* (Moscow News). Russia's secret CWA/CW programme, which violated the CWC that Russia was about to sign (Kloske & Witkiewicz, 2019; Nepovimova & Kuca, 2018), was again mentioned in this article. This time, the revelation received significant media coverage and led to Mirzayanov's arrest and later imprisonment by the Russian secret services (Kloske and Witkiewicz, 2019; Tucker, 2006).

In 1995, in an article included in a report by the Stimson Center, Dr Mirzayanov provides the names of some of the neurotoxic agents produced by the Soviets in the 1970s, details about their programmes and the scientists that developed them, as well as the sites of the facilities where the compounds were tested and synthesised and their status of production (Smithson, Mirzayanov, Lajoie & Krepon, 1995). These compounds are known as A-series agents because their names are formed by combining the letter "A" with a set of three digits (e.g. A-230). The same report also states that the order to intensify and expand the activities of the secret project code-named *"Novichok"* came from high-ranking Russian officials.

4.1. A-series nerve agents

In the book *State Secrets: An Insider's Chronicle of the Russian Chemical Weapons Program*, Mirzayanov states that, between 1971 and 1973, Dr Kirpichev and his team produced a set of neurotoxic agents derived from the G-series and V-series compounds, which they called the A-series (Mirzayanov, 2008). According to the exiled Russian scientist, the first compound synthesised was A-230 (Figure 3), a compound similar to sarin and soman with a nitrogen substituent attached to the phosphorus atom instead of the -OR substituents[7]. The compound's toxicity was 5 to 8 times higher than RVX (Franca et al., 2019; Pitschmann, 2014; Tucker, 2006).

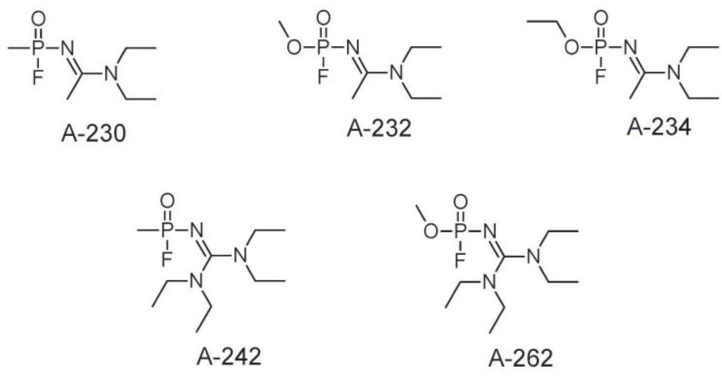

Figure 3 – Molecular structures of the A-series compounds synthesised by Dr Kirpichev, according to Mirzayanov

Source: Franca et al. (2019).

[7] The -OR notation represents a structure in which the oxygen atom (O) is followed by a chemical group represented by the letter R. In the case of sarin, "R" refers to the isopropyl group of the *O-isopropyl* substituent. In the molecular structure of soman, "R" refers to the pinacolyl group of the *O-pinacolyl* substituent.

As a result, more than a hundred structural variants of A-230 were synthesised and tested. However, only five of these molecules were stable enough to be of interest to the military (Tucker, 2006). According to the structures described by Dr Mirzayanov (Figure 3), the A-232 and A-234 compounds were the methoxy and ethoxy analogues of A-230. These compounds had a similar toxicity to RVX but were more volatile and less stable in the presence of moisture (Franca et al., 2019; Nepovimova & Kuca, 2018; Smithson et al., 1995). The other two molecules that were synthesised (both of which were solid agents) were called A-242 and A-262 and are the guanidine analogues of A-230 and A-232, respectively (Mirzayanov, 2008).

However, as the *Foliant* programme was highly classified, the data available in the literature were collected from several sources and the structures of the actual compounds that were synthesised have not yet been definitely identified. After Mirzayanov, other authors, such as Hoenig (2007) and Ellison (2007), have suggested possible structures for the A-series agents (Figure 4). Here, the substituent that contains nitrogen is not directly attached to the phosphorus atom, but to an oxygen atom. These compounds' substituents also contained several atoms of the halogen family (in this case: chlorine [Cl] and fluorine [F]).

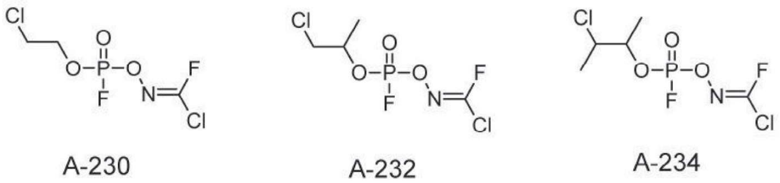

Figure 4 – Molecular structures of the A-series compounds proposed by Hoenig and Ellison
Source: Franca et al. (2019).

Notwithstanding this, according to Franca et al. (2019), it is commonly accepted that all A-series agent structures are derivatives of one of the three base structures in Figure 5. However, the same author also states that not only was the Russian project highly classified and shrouded in secrecy, but also fake structures may have been leaked intentionally by counterintelligence services, therefore it will be difficult to confirm the accuracy of these strucutures.

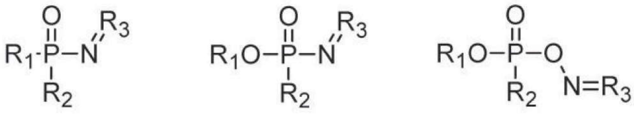

Figure 5 – Base structures of A-series compounds that have already been published
Source: Franca et al. (2019).

4.2. The *Novichok* Programme

In March 1983, a secret decree issued by the Central Committee of the Communist Party of the Soviet Union and the Council of Ministers of the USSR tasked the GosNIIOKhT with developing binary weapons[8] based on A-series agents (Tucker, 2006). With this measure, the USSR aimed to develop technology that enabled it to counter the US', as the latter already had three binary weapons under development at the time (Franca et al., 2019; Pitschmann, 2014; Smithson et al., 1995; Tucker, 2006).

RVX, referred to as R-33 or Substance-33 within the Russian research programme, was the first compound developed in binary form (Mirzayanov, 2008; Smithson et al., 1995; Tucker, 2006). The weapon was given the code name *Novichok* (Новичóк in Cyrillic), which means "newcomer", and the secret project to develop these weapons became known as the "*Novichok* programme".

As there is currently no official definition for the term "*Novichok*", nor any rules concerning its use[9], *Novichok* can have different meanings for different authors[10]:

– It can refer to a molecule: the chemical precursors that are mixed to produce the reaction that takes place in binary weapons, the intermediate molecules generated by that reaction, or its final products, i.e. A-series agents;
– It can refer to a set of compounds: A-series agents;
– It can refer to a type of weapon: the binary weapons developed in Russian secret projects, including both the munition and the precursor compounds.

According to Mirzayanov, after developing the binary analogue of RVX, in 1989 Russian scientists also developed A-232 in binary form. This agent, known as *Novichok-5*, was the first binary CW approved by the Soviet Army (Smithson et al., 1995). The binary analogue of RVX, which some authors refer to as *Novichok-#*, was developed and tested before *Novichok-5* but was only approved for use as a CW in 1990 (Mirzayanov, 2008; Smithson et al., 1995). A third binary weapon based on the A-234 agent, called *Novichok-7*, was developed by Professor Georgi Drozd in 1993 (Smithson et al., 1995; Tucker, 2006). However, it was never produced in large quantities because it was never approved as a CW by the Soviet authorities.

4.3. Use of CW in the 21st century

The first known case of poisoning with an A-series agent occurred in the 20th century. The victim was Russian scientist Andrei Zheleznyakov. In the late 1980s, Zheleznyakov was accidentally exposed to *Novichok-5* due to a hood vent malfunction (Chai, Hayes, Erickson & Boyer, 2018; Nepovimova & Kuca, 2018; Smithson et al., 1995). In addition to acute symptoms, Zheleznyakov suffered chronic injuries, including liver and neurological damage, and died five years after the accident (Nepovimova & Kuca, 2018).

In the 21st century, the world witnessed the first intentional use of A-series nerve agents as a CW.

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[8] The term "binary weapons" refers to "binary chemical munitions", which, according to Croddy, Wirtz and Larsen (2004) "[...] consist of two separate components that by themselves are relatively nontoxic, but when mixed together produce a toxic chemical warfare (CW) agent."

[9] Not only is there no official definition / application of the term *Novichok*, there are inconsistencies in the use of the singular and plural forms ("*Novichok* agents" is often used instead of "*Novichoks* agents").

[10] In this article, *Novichok* refers to the binary weapon. When referring to a molecule or set of molecules, the term used will be the agent (e.g. A-230) or the "A-series" classification, respectively. When citing authors who use the term with a different meaning, it will be enclosed in inverted commas and followed by the in-text citation.

On 4 March 2018, in Salisbury, England, former Russian spy Sergei Skripal and his daughter Yulia were found unconscious on a park bench and were hospitalised with symptoms of exposure to a neurotoxic agent (Chai et al., 2018; Nepovimova & Kuca, 2018; Patocka, 2018; Vale et al., 2018). The police officer who assisted them, Nicholas Bailey, was also hospitalised with similar symptoms (Vale et al., 2018). A few days later, it was reported that the victims had been exposed to a nerve agent (Chai et al., 2018; Vale et al, 2018), and on 12 March, then Prime Minister Theresa May stated that, based on the findings of experts from the Defence Science and Technology Laboratory (DSTL), a "military-grade nerve agent of a type developed by Russia" had been used in the attack (Patocka, 2018; Peplow, 2018; Vale et al, 2018), allegedly agent A-234 (Bhakhoa et al., 2019; Costanzi & Koblentz, 2019; Harvey et al., 2020). In response to the attack, the UK requested technical assistance from the OPCW under Article VIII of the CWC, and a team of experts was sent to England from 21 to 23 March (OPCW, 2018b). On 12 April, the OPCW issued a report that confirmed the findings of the UK report of the previous month (OPCW, 2018b). Despite the high purity of the compound used in the poisoning attempt (OPCW, 2018b), all three victims recovered. Sergei Skripal was the last to be discharged from hospital on 18 May.

Naturally, several international organizations discussed the incident and made official declarations publically condemning the events and asking Russia to respond to the UK's allegations (Council of the European Union, 2018; European Council, 2018; Global Affairs Canada, 2018; United Nations Security Council, 2018a, 2018b). As a result, Russian diplomats were expelled from several countries and Russia responded by expelling members of the diplomatic staffs of those countries (Lusa, 2018). On 16 October 2018, the Council of the European Union published its decision to impose restrictive measures on four individuals involved in the incident, which have been extended until 16 October 2021 (Council Decision 2020/1466).

Almost four months after this incident, on 30 June, in Amesbury, 13 km from Salisbury, a British couple was hospitalised with symptoms of neurotoxic poisoning (OPCW, 2018c; Pita, Anadón Romero & Kuca 2020). The investigation found that Charles Rowley and Dawn Sturgess were allegedly poisoned after handling a perfume bottle they had found in a Salisbury public garden (Costanzi & Koblentz, 2019; Pita et al., 2020). The findings of the DSTL indicated that the substance detected matched the one that was used to poison the Skripals. After a new request for technical assistance and the succeeding analysis of biomedical and environmental samples, the OPCW confirmed the DSTL findings, and added that the compound in the perfume bottle had a purity of 97-98% (OPCW, 2018c). This incident had more serious consequences. As Dawn Sturgess had sprayed the contents of the bottle on her wrists, she was exposed to a higher dose and died nine days later in a local hospital (Costanzi & Koblentz, 2020). Charles Rowley survived, despite being hospitalised multiple times.

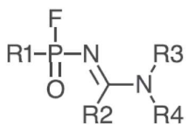
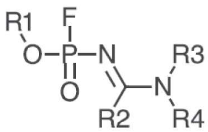
Two years later, A-series agents were again discussed in the media. On 20 August 2020, Alexei Navalny, a politician who opposed Vladimir Putin's regime, felt ill while travelling from Tomsk to Moscow. As the symptoms worsened significantly during the flight, the plane landed in Omsk (Siberia) and Navalny was admitted to a local hospital (Pushkarskaya, Berdnikova, Sazonov, Soshnikov & Churmanova, 2020). Although he was hospitalised in the acute poisoning wing, the Russian medical team stated that no traces of toxic compounds were found in the tests and that the illness may have been caused by a metabolic disorder. However, on 22 August the Russian politician was moved to the Charité Hospital in Berlin. Two days later, the German medical team revealed that the results of the toxicology tests confirmed that Navalny was poisoned (Pushkarskaya et al., 2020). On 2 September, the German government announced that the tests conducted in German military laboratories had produced "unequivocal evidence" that Navalny was poisoned with a "Novichok-type nerve agent" (Reis, 2020; Stone, 2020). These findings were delivered to the OPCW on 3 September, and on the following day German Ambassador Gudrun Lingner sent a letter to the Director-General of the Organization, requesting technical assistance support under Article VIII of the OPCW (OPCW, 2021). The OPCW team of experts travelled to Berlin to oversee the collection of blood and urine samples from Navalny, which were maintained under the OPCW's chain of custody and sent to the OPCW laboratory, where they were stored until the official request for analysis by the German authorities was received. On 11 September, the samples were sent to two laboratories selected by the OPCW, which confirmed the findings of the German experts (OPCW, 2020).

Once again, international organizations issued declarations condemning the attempted assassination of the Russian politician (Council of the European Union, 2020; G7 Foreign Ministers, 2020; Global Affairs Canada, 2020) and the European Union applied restrictive measures to the individuals involved in the incident through an amendment to the decision sanctioning the individuals involved in the Salisbury incident (Council Decision 2020/1482).

4.4. Amendment to the CWC

After the Salisbury incident, two proposals to update the OPCW's Schedule 1 were submitted to the Conference of States Parties (Costanzi & Koblentz, 2019, 2020). The first was a joint proposal submitted by the US, Canada and the Netherlands on 25 October 2018 (OPCW, 2019c), requesting the inclusion in Schedule 1 of two families of compounds described by Mirzayanov (Table 4), alkylphosphonamidofluoridate and alkylphosphoramidofluoridate, both of which have an amidine branch attached to the core of the molecule (Costanzi & Koblentz, 2020). The suggested terminology covers a broad group of molecules, as there are four substituent groups that can have multiple structures.

Table 4 – Additions to the CWC Schedule 1 proposed by the US, Canada and the Netherlands

Chemical name	*Structure*
P-Alkyl (H or $\leq C_{10}$, incl. cycloalkyl) *N*-(1-(dialkyl ($\leq C_{10}$, incl. cycloalkyl) amino) alkylidene)) (H or $\leq C_{10}$, incl. cycloalkyl) phosphonamidic fluorides and corresponding alkylated or protonated salts	 #
O-Alkyl (H or $\leq C_{10}$, incl. cycloalkyl) *N*-(1-(dialkyl ($\leq C_{10}$, incl. cycloalkyl) amino))alkylidene (H or $\leq C_{10}$, incl. cycloalkyl) phosphoramidofluoridates and corresponding alkylated or protonated salts	 #

Where: R1 and R2 = H or alkyl group with 10 or fewer carbon atoms (including cycloalkyl groups)
R3 and R4 = alkyl group with 10 or fewer carbon atoms (including cycloalkyl groups)

Source: Adapted from Costanzi and Koblentz (2019).

On 22 November 2018, during the Fourth Review Conference of the CWC, US Ambassador Kenneth D. Ward stated that the proposal aimed to add two families of "*Novichok* chemical agents" to the CWC Schedules, including the compound used in the Salisbury incident (OPCW, 2018d). This statement appears to confirm the information that had already been published on the structure of the agent used in the Skripal poisoning, which allegedly matched the A-234 compound described by Mirzayanov (Costanzi & Koblentz, 2019).

The second proposal was submitted by the Russian Federation on 29 November 2018 (and amended on 21 January 2019) and included five additions to Schedule 1 (Costanzi & Koblentz, 2019, 2020; OPCW, 2019c). Although the OPCW did not publicly disclose the details of the Russian proposal, its contents are described in: i) a presentation delivered by Alexander Shulgin, the Permanent Representative of the Russian Federation to the OPCW, and Russian chemical weapons expert Victor Kholstov [entries 1 and 2 of the proposal]; and ii) a document from the U.S. Department of Commerce Bureau of Industry and Security [entries 3, 4 and 5] (Costanzi & Koblentz, 2019). The presentation revealed that the proposed compounds corresponded to agents A-232 and A-234 (entry 1) and A-230 (entry 2), according to the structures provided by Mirzayanov. The document issued by the US agency revealed that: entry 3 described a group of compounds containing the guanidine structure and the P-alkyl substituents (agent A-242 and its analogues, according to Mirzayanov); entry 4 included two families of carbamate compounds; and entry 5 corresponds to a set of molecules whose structure matches the ones proposed by Hoenig (2007) and Ellison (2007).

After some breakthroughs and setbacks which included amendments to the Russian proposal, such as reducing entry 4 to a single compound and removing entry 5, both proposals were approved at the Twenty-Fourth Conference of States Parties in 2019 (OPCW, 2019a, 2019b). With this decision, four new entries were added to Schedule 1 (13 to 16), all of which are classified as Toxic Chemicals (Part A). These amendments entered into force on 7 June 2020, 180 days after the UN Secretary-General was officially informed (Costanzi & Koblentz, 2020) and about a month before the attempted poisoning of Alexei Navalny.

Therefore, all compounds covered by the new entries are now subject to the OPCW's verification measures, and all States Parties in possession of such compounds are obliged to declare them.

This historic amendment to the CWC's Schedule 1 attests to the scope and resilience of this treaty, as the mechanism to update it has been used effectively, and thus it can always be adapted to new developments. Therefore, in the future, the treaty can be updated to include other A-series compounds such as: i) the A-262 structure proposed by Mirzayanov and its analogues, ii) entry 15 can be expanded to add the analogues of compound A-242, which were included in the original Russian proposal.

However, the use of these new agents was already prohibited by the CWC before the recent amendments to Schedule 1, as any chemical compound used with the intent to "[...] cause death, temporary incapacitation or permanent harm to humans or animals [...]" due to "[...] its chemical action on life processes [...]" is considered a CW (OPCW, n.d.). This concept is designated the *General Purpose Criterion*.

5. Final reflections

History has shown that the use of chemical compounds as weapons is not a novel phenomenon, but one that has endured over time. The development of new technologies and the emergence of global conflicts led to an escalation in the production and use of these compounds, and, after countless human lives were lost during WWI, to the adoption of the CWC. Despite being one of the most successful global disarmament treaties, CW are not a thing of the past. The events of recent years have shown that, to prevent these types of weapons from being used again, States Parties must not only focus on disarmament but also on non-proliferation.

The poisonings / assassination attempts in Salisbury (UK) and Tomsk (Russia) in 2018 and 2020, respectively, with the A-series nerve agents known as *Novichok*, posed different challenges to the OPCW and its States Parties: technical challenges arising from the need to provide methods and technologies capable of detecting, identifying and quantifying this type of agents; political, diplomatic and legal challenges arising from the fact that a (new) CW was again used against humans; and challenges to the framework of the treaty, which had to be amended for the first time in the history of the Convention to add this new class of CW.

Therefore, the chemical threat cannot, under any circumstances or at any time, be ignored or considered "extinct" because the march of science never stops and there is always another chemical compound to synthesise! As Aldous Huxley wrote in *Brave New World*: "Every change is a menace to stability. [...] every discovery in pure science is potentially subversive; even science must sometimes be treated as a possible enemy".

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