

## Preventing chemical weapons as sciences converge: Focus must extend beyond 20th-century technologies

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Stark illustrations of the dangers from chemical weapons can be seen in attacks using toxic industrial chemicals and sarin against civilians and combatants in Syria and toxic industrial chemicals in Iraq, as well as more targeted assassination operations in Malaysia and the United Kingdom, employing VX and novichok nerve agents, respectively. Concerns about such malign applications of chemical technology are exacerbated by the unstable international security environment and the changing nature of armed conflict, “where borderlines between war, civil war, large-scale violations of human rights, revolutions and uprisings, insurgencies and terrorism as well as organized crime are blurred” (1). It is thus essential that the global community regularly review the nature and implications of developments in chemistry, and its convergence with the life and associated sciences, and establish appropriate measures to prevent their misuse. With the parties to the Chemical Weapons Convention (CWC) convening a Review Conference to address such issues beginning 21 November 2018, we highlight important scientific aspects (2).

### COMPREHENSIVE PROHIBITION

The CWC is a multilateral treaty in effect since 1997 that proscribes the development, production, stockpiling, transfer, and use of chemical weapons “under any circumstances” and requires their destruction within a specified time period. The CWC allows the use of toxic chemicals for a range of industrial, agricultural, research, medical, pharmaceutical, or other peaceful purposes, including law enforcement, as long as the “types and quantities” of chemicals employed are “consistent with such purposes.” The CWC has declaration requirements (obliging States to detail facilities that produce or use certain chemicals of concern, grouped into three “schedules,” based on the risk they pose to the CWC), industry inspections, and other verification measures to ensure that toxic chemicals and related technologies are not misused in weapons production and to investigate alleged chemical weapons use.

The Organisation for the Prohibition of Chemical Weapons (OPCW), which is the implementing body of the CWC, comprises the 193 State Parties and a Technical Secretariat that provides technical assistance to States, routinely inspects relevant State and commercial industrial facilities, and monitors activities to ensure compliance. It was awarded the Nobel Peace Prize in 2013 for overseeing and facilitating the verified destruction of most of the declared chemical weapons stocks produced in the last century—to date totalling more than 96% (69,750 metric tons) of the declared stockpiles of chemical agents. Now that this first phase of the CWC’s implementation is nearing completion, the OPCW has to increasingly focus on preventing the re-emergence of chemical weapons. Thus, in addition to combatting possession and employment of 20th-century chemical weapons types, the OPCW must also address a changing external environment where the risks associated with toxic chemicals and their potential misuse as weapons are becoming more diffuse and less well defined in terms of chemical compounds or dissemination methods. To respond effectively to such shifts and maintain the comprehensive nature of the chemical weapons prohibition, the OPCW should prioritize key issues below.

## Ensure effective implementation of the General Purpose Criterion

Although the CWC includes three schedules of toxic chemicals for the application of verification measures, the scope of the CWC is not constrained to these schedules but by its General Purpose Criterion (GPC), which prohibits misuse of toxic chemicals based on intent rather than on this limited list of chemicals (3). The CWC negotiators sought to ensure that the CWC could accommodate, and the States Parties be able to respond to, future developments in chemistry, biology, and associated sciences and technologies. Consequently, “even toxic chemicals whose existence is not yet known are covered,” while “legitimate uses of all toxic chemicals and chemicals from which they can be made” are protected (4).

But there is contested interpretation of the GPC as to the range of chemicals and delivery mechanisms that could be employed for law enforcement, and the nature of what constitutes legitimate use. The upcoming Review Conference should thus establish an Open-Ended Working Group (OEWG) involving scientific experts to design guidelines to prevent research, development, production, and employment activities that, while purportedly intended to support law enforcement, would undermine the prohibitions of the CWC. The OEWG should consider existing obligations under international law, notably, international human rights law (IHRL), and their bearing on the CWC. The OEWG should specifically address the following:

1) Riot control agents (RCAs). The CWC defines RCAs—such as tear gas and pepper spray—as “any chemical not listed” in one of its three schedules that can produce “rapidly in humans sensory irritation or disabling physical effects which disappear within a short time following termination of exposure.” Thus, chemicals should only be employed as RCAs if there is solid scientific evidence to show that such agents are not dangerous to humans when used in an appropriate manner. The CWC permits their use for “law enforcement including domestic riot control” (5), as long as the “types and quantities” (6) are consistent with such purposes. However, a recurring concern documented by the medical community and human rights monitors has been the widespread misuse of RCAs by police and security forces in excessive quantities, including in hospitals, prisons, homes, and automobiles, where targeted individuals cannot disperse. In such situations, serious injury or death can result from toxic properties of chemicals or from asphyxiation.

Although a variety of chemicals were developed, considered, or used as RCAs in the past century, the OPCW Scientific Advisory Board (SAB, comprised of independent experts) clarified that only 17 chemicals from the 60 it examined were consistent with the RCA definition under the CWC (7). For example, certain States designated Adamsite (DM) as an RCA, but it has been removed from this category because of its danger to human health [(7), appendix 3]. The OEWG should now clarify the nature and scope of “law enforcement” activities and develop guidance as to “types and quantities” of RCAs that can legitimately be used in such circumstances, highlighting obligations under IHRL.

2) Delivery systems. If the OPCW does not take appropriate action on RCAs, the situation could dramatically worsen as a result of ongoing development and marketing of systems capable of delivering far greater amounts of RCAs (and potentially other toxic chemicals) over wider areas or more extended distances than current standard law enforcement delivery mechanisms, such as hand-held sprays, grenades, and single launched projectiles. Such new systems include large-capacity spraying devices, automatic grenade launchers, multibarrel projectile launchers, large-caliber RCA projectiles, and unmanned ground or aerial vehicles capable of carrying spraying devices or projectile launchers (8). The OEWG should develop criteria for determining which means

of delivering and dispersing RCAs are inconsistent with the purpose of law enforcement and should thus be prohibited. Such prohibited means of delivery should, at a minimum, include artillery shells, aerial bombs, mortar shells, and cluster munitions.

3) Incapacitating chemical agent (ICA) weapons. Although the CWC permits use of appropriate types and quantities of RCAs for law enforcement, certain countries have conducted research into weapons employing other distinct toxic chemicals, so-called ICAs. Not separately defined under the CWC, ICAs can be considered as a range of toxic chemicals—only one of which [3-quinuclidinyl benzilate (BZ) and two of its immediate precursors] is currently scheduled—including anaesthetics and other pharmaceutical chemicals that are purportedly intended to act on the body's core biochemical and physiological systems, notably the central nervous system (CNS), to cause prolonged but non-permanent disability. Such CNS-acting chemicals can produce unconsciousness, sedation, hallucination, incoherence, disorientation, or paralysis. With inappropriate doses, however, death can result. Leading medical and scientific organizations have highlighted grave dangers to health and well-being of such weapons (9); in the only confirmed example of their large-scale use, an aerosolized mixture of two anesthetics—carfentanil and remifentanil—employed by Russian security forces to end the Moscow theatre siege of October 2002 caused the deaths of 125 of the 900 hostages (10).

As the U.S. Ambassador to the OPCW noted in October of this year, “The United States and many other States Parties are seriously concerned that some States may be developing these chemicals for warfare...while cloaking their efforts as legitimate activities such as law enforcement” (11). The U.S. concern is reflected in a recent Department of Defense solicitation that “seeks to develop field diagnostic capabilities for detection of exposure to the ever-growing opioid class of chemical threat agents.”

The chemical threat spectrum includes bioregulators and toxins, and our increasing understanding of the CNS is likely to uncover many more potential targets and agent classes that might be weaponized. Scientists should be aware of such possibilities and be able to alert their CWC National Authority and the OPCW Technical Secretariat to potential dangers. The OEWG could determine either that development, stockpiling, transfer, and use of ICA weapons for law enforcement are prohibited under the CWC or that such actions are permitted but should be severely restricted.

Improve OPCW monitoring and risk assessment of science and technology

In 2011, an expert panel recommended that the OPCW should “improve and widen the scope of monitoring and evaluating developments in chemical science and technology” (12). In 2013, in response to such concerns, the OPCW appointed a Science Policy Adviser at the Technical Secretariat. In addition, over the past 5 years, the SAB has regularly provided technical reports and briefings on key scientific and technological (S&T) developments. Building upon these advances, and informed by SAB recommendations (13), the OPCW should consider further measures to strengthen the Technical Secretariat's capability to monitor and forecast S&T developments and their implications, and to strengthen its ability and mandate to proactively bring specific cases of concern to the attention of the States Parties. However, this is not something that the OPCW can do alone, given the range of scientific disciplines and technologies that need to be monitored, their complexity, their rapidity of advance, and the geographical scope of research and development. Thus the nongovernmental chemical and life scientific community, in particular, has an important role to play by undertaking technology tracking of generic trends in technologies of relevance to the CWC (as has

been undertaken previously by the International Union of Pure and Applied Chemistry in preparation for previous CWC Review Conferences), and by undertaking targeted research into S&T developments of particular concern, for example, in the fields of medicinal chemistry, pharmacology, synthetic biology, nanotechnology, and, as undertaken by the Royal Society, neuroscience (9).

## IMPLEMENTATION AND VERIFICATION

Advances in S&T may have several effects on national implementation of the CWC by its States Parties and on how the OPCW verification mechanisms function, which the Review Conference should address.

### Update industry verification measures

OPCW verification measures currently focus on the list of scheduled chemicals, which were previously identified from past State chemical weapons programs. But new production pathways to old chemical warfare agents may become feasible as a result of technological advances; alternatively, new potential chemical warfare agent types may become relevant involving toxic chemicals not listed on any of the schedules. Consequently, the routine industry verification regime (as well as the analytical methods and databases available for challenge inspection and for investigation of alleged chemical weapons use) need to be adapted to these new technological and chemical realities. The SAB has suggested that “efforts to ensure that the verification regime remains effective would benefit from more extensive engagement with technical experts from industry, and review of industry-focused research and development, including the driving forces for adoption of new technologies into industrial processes” (13). Favourable consideration should also be given to updating the schedules themselves (13), at least to provide indicators of the new or additional types of potential chemical agents (and their precursors) of concern, such as the novichok agent (and its associated families).

### Other chemical production facilities

Other chemical production facilities (OCPFs) are chemical plants that do not currently produce, but are capable of manufacturing, chemical warfare agents or precursors. At present, a small fraction of declared OCPFs are selected for verification by the OPCW; the Review Conference should consider authorizing a substantial increase in OCPF inspections per year. The OPCW should also be directed to refine the process of site selection so as to target inspections on multipurpose chemical plants that pose the greatest risk of being utilized for prohibited purposes.

### Biological and biologically mediated processes for production of discrete organic chemicals

Some products and processes used by the biomanufacturing industry are as relevant to the CWC as those used by other OCPF facilities, including those the Technical Secretariat considers pose notable risks. Thus, the SAB has consistently recommended that biomanufacturing of chemical products should be covered under the scope of the CWC. However, States Parties have yet to agree on how to treat these types of production processes and facilities. The Review Conference should follow SAB advice and establish measures to determine the relevance of various types of biomanufacturing processes and facilities for CWC verification purposes.

## PREVENTING AND RESPONDING

The OPCW should continue improvements in the operational and technical capacity of the Technical Secretariat to conduct challenge inspections and investigations of alleged use of chemical weapons, with an increased focus on chemical forensics. An important development in this regard was the June 2018 decision to empower the OPCW to develop an attribution mechanism to determine who conducted a chemical attack (14). Ongoing work by the SAB into opportunities and difficulties associated with chemical forensics will enable the OPCW to most effectively utilize new tools and methods. Such work, which would benefit from wide consultation with scientific experts, must be complemented by efforts to compile, expand, and properly curate the databases of reference spectra and collections of reference materials that will be needed for such forensic analysis.

The SAB highlighted the critical role of biomedical samples in investigations of alleged use of toxic chemicals and recommended that the Technical Secretariat should “actively encourage further research on potential markers of exposure to such chemicals.” The OPCW should also build on the considerable progress made toward developing a network of designated laboratories for the analysis of biomedical and biological samples (15). Advances in other fields could also facilitate more effective evidence collection, for example, exploring the potential of unmanned aerial vehicles to support reconnaissance, detection, and chain of custody. The OPCW should also consider how best to strengthen the resilience of States against hostile use of toxic chemicals. This could include expanding the number of viable national protective programs supported by OPCW training and capacity building, and the establishment of well-equipped regional capacities for effective response to the use of chemical weapons or the accidental release of toxic chemicals.

## SCIENTISTS AND AN EVOLVING OPCW

The OPCW faces the task of deciding how best to evolve to prevent the reemergence of chemical weapons in a period of rapid scientific change and unstable international security. There is growing recognition within the OPCW of the vital importance of engaging with and ensuring the support of the world-wide scientific community, in particular via relationships with professional societies (13). Chemical and life scientists could play their part by being better informed of the issues at stake, and by ensuring that their colleagues and students are alerted to the dangers of the misuse of dual-use technologies and are implementing relevant ethical codes, codes of conduct, and the Hague Ethical Guidelines recently developed by the OPCW to promote a culture of responsible conduct in the chemical sciences and to guard against the misuse of chemistry for malign intent.

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