OPCW **Conference of the States Parties**

Third Review Conference RC-3/WP.1
8 – 19 April 2013 27 March 2013
ENGLISH only

REPORT OF THE SCIENTIFIC ADVISORY BOARD ON DEVELOPMENTS IN SCIENCE AND TECHNOLOGY FOR THE THIRD REVIEW CONFERENCE

REMARKS BY THE CHAIR

(Stefan Mogl, Spiez Laboratory, Switzerland, Chair of the Scientific Advisory Board)

1. The Scientific Advisory Board (SAB) of the Organisation for the Prohibition of Chemical Weapons (OPCW) provides specialised advice in relation to science and technology to the OPCW Director-General. Every five years OPCW Member States conduct a review of the operation of the Chemical Weapons Convention (hereinafter "the Convention")—a review conference—and they will do so for the third time in April 2013. The SAB supports this review process with an analysis of developments in science and technology. Following the practice for the previous review conferences, the SAB prepared a report for the Third Review Conference, taking into account a variety of sources, including a dedicated workshop organised by the International Union of Pure and Applied Chemistry (IUPAC), the National Academy of Sciences and the OPCW at Spiez Laboratory in Switzerland, in February 2012.

Convergence of chemistry and biology

2. The convergence of the sciences and in particular the convergence of chemistry and biology combined with rapid advances in the life sciences affect the implementation of the Convention in different areas. The commercial production of chemicals, for example, is increasingly employing biologically mediated processes. Other new technologies make the chemical synthesis of simple organisms and the design or redesign of biological systems possible, which may simplify the production of certain classes of chemicals including toxins and bioregulators. The SAB considers it unlikely that these technological developments will be applied to the production of classic chemical-warfare agents such as blistering agents and nerve agents for which proven methods exist. Instead, the Board expects from convergence, benefits in the protection against chemical weapons. However, toxins and bioregulators fall between the Convention and the Biological Weapons Convention (BWC) and the SAB therefore proposes to strengthen the cooperation between the experts on the two treaties and to keep the convergence of the sciences under review.

Accelerated discovery of chemicals

3. Concerns were raised in the past about the accelerated discovery of new biologically active chemicals as a result of new approaches and methods in drug design—such as

combinatorial and other forms of parallel multi-compound synthesis—that could lead to the discovery of prototypes for new toxic chemicals. The SAB does not negate that among the millions of compounds being screened today, potential candidates for toxic chemicals can be discovered but it emphasises that these new methods generate data based on in vitro screening that may not actually reflect toxicity in vivo. This is in contrast to the animal testing that was used in the development programmes for toxic chemicals during the 1950s to the 1970s on a much smaller number of compounds. The Board concludes that today's large in-house databases in pharmaceutical companies and related institutions pose no greater risk to the Convention than the much smaller databases—based mainly on in vivo testing—that existed prior to the Convention's entry into force in 1997.

Nanotechnology

4. The SAB expects that advances in nanotechnology will help improve countermeasures against chemical-warfare agents in detection, diagnostics, physical protection and decontamination. The Board cannot confirm concerns about enhanced acute toxicity of nano-size materials because too little is known today. In the view of the SAB nanotechnology is unlikely to provide a dramatic improvement in the military utility of existing chemical agents, but it could be exploited in the development of new agents and advanced delivery systems. For example, nanomaterials are investigated for the smart delivery of therapeutic agents (see below).

Technologies for the delivery of toxic chemicals and drugs

5. The pharmaceutical industry is developing methods to administer drugs for medical purposes via the respiratory system through inhalation. A potential growth area is the use of porous nanoparticles acting as carriers. In the form of a particulate aerosol nanoparticles deliver the drug into the alveolar regions of the lungs from where they are absorbed into the blood. Advancements further include engineering of nanomaterials for controlled drug release, enhanced penetration of the blood-brain barrier and targeting specific organs or cells. The SAB will keep this technology under review.

6. In relation to the classic delivery of toxic chemicals by munitions the SAB noted with some concern isolated reports of the commercial availability of munitions that apparently were designed to deliver large amounts of riot control agents over long distances. A range of other devices that might be attractive for the dissemination of chemical weapons and biological-weapons agents by non-State actors continue to receive attention from observers.

Production technologies

7. Technological advances in production methods for industrial chemicals are relevant to the Convention because they could be utilised for the production of toxic chemicals. Microreactors and small-scale flow reactors have been mentioned in the past as a potentially critical development for the implementation of the Convention. The technology has made significant advances in the past five years and such reactors have become more prevalent in research and development laboratories. They are however not yet widely used in industry and their integration into industrial scale production has been slower than some observers predicted. In the view of the SAB, microreactors, at this point in time, are not generic reactors for an easy "off-the-shelf"

solution to chemical production and they show particular limitation for handling solids. While microreactors offer many technical advantages for certain types of reactions, utilising them for a particular process requires experience and technical expertise. In the view of the SAB, the technology continues to require monitoring in order to assess the impact it may have on the verification regime of the Convention.

Schedules of Chemicals

8. The Convention contains in the Annex on Chemicals three schedules listing the chemicals which fall under routine verification by the OPCW. The SAB made no specific recommendation regarding a review or an amendment of these schedules as has been proposed by some observers. It emphasised that the definition of toxic chemicals in the Convention would cover all potential candidate chemicals that might be utilised as chemical weapons. Regarding new toxic chemicals not listed in the Annex on Chemicals but which may nevertheless pose a risk to the Convention, the SAB makes reference to "Novichoks". The name "Novichok" is used in a publication of a former Soviet scientist who reported investigating a new class of nerve agents suitable for use as binary chemical weapons. The SAB states that it has insufficient information to comment on the existence or properties of "Novichoks".

9. In relation to Schedule 1 chemicals the SAB alerts Member States that certain Schedule 1 chemicals—the chemical warfare agents sulfur and nitrogen mustard—may be present in industrial processes under certain conditions. Literature studies indicate that nitrogen mustards and sulfur mustards are utilised as captive intermediates in multi-step synthesis more frequently than previously thought. Based on the same study the SAB concluded furthermore that if starting materials in industrial processes contain the respective precursor chemicals of nitrogen and sulfur mustards, both groups of Schedule 1 chemicals may be formed as impurities when chlorinating agents are present. In the view of the SAB such mixtures pose no threat to the object and purpose of the Convention but may have to be addressed from a policy perspective.

10. The SAB has been following the discussions on chemical incapacitants for law enforcement purposes and is aware of concerns that have been raised about the possibility of such agents being used for purposes prohibited by the Convention. The Board discussed some of the scientific aspects and emphasised that labelling such chemicals as "non-lethal" is inappropriate, as toxicity is a matter of dosage for all chemicals. There also seem to be pronounced differences between animal species in the response to certain type of incapacitants. The SAB recalled some of the technical complexities regarding the safe use of such agents that have been reported in expert meetings. These findings include the variability in human response to potential incapacitants, which is due to a number of factors (age, gender, medical precondition, etc.), as well as the problem of uneven dissemination during field use of any agent and the resulting difficulty to predict an actual dose for people exposed. Because incapacitants could become the subject of an investigation of alleged use, the SAB recommends that the OPCW should develop the necessary analytical capability to verify such toxic chemicals.

Verification technology

11. The OPCW undertakes analysis of samples onsite as part of its inspection activities. In the view of the SAB, the Organisation has demonstrated in the past five years that equipment and procedures are fit for purpose. Samples were collected and analysed regularly during chemical industry inspections. Further progress in sample preparation as well as analysis methods will reduce analysis time and increase the number of samples that can be analysed within the time constraints of an inspection. Analysis results are based on the OPCW Central Analytical Database (OCAD), which serves as the OPCW's reference library. The SAB is pleased that the contents of the OCAD have grown significantly in the past five years, extending the group of chemicals that can be identified during onsite analysis. However, the SAB emphasises that strictly limiting the OCAD to the scheduled chemicals listed in the Annex on Chemicals may prevent inspectors from detecting other toxic chemicals with weapons potential, which may become necessary for example during an investigation of alleged use of chemical weapons.

12. Currently 22 laboratories are certified by the OPCW for the verification analysis of chemical weapons related samples. These designated laboratories would receive samples from an OPCW inspection where offsite analysis is considered appropriate, or in cases of investigations into alleged use of chemical weapons. They must provide analytical evidence for the presence or absence of chemicals that may be the subject of a potential violation of the Convention. Significant progress has been achieved in establishing analytical methods and identification criteria for the two schedules 1 toxins listed in the Annex on Chemicals, ricin and saxitoxin. In the view of the SAB, attention should be given also to the identification of non-scheduled or novel toxic chemicals. The SAB recommends preparing for scenarios where there might be evidence of prohibited use of toxic chemicals but no scheduled chemicals can be found. In this context, the SAB considers the increasing availability of high-resolution mass spectrometers (HRMS) an important recent development. The ability to perform accurate mass measurements will assist substantially the analysis of new toxic chemicals that are not contained in analytical databases such as the OCAD.

13. The SAB is satisfied with the changes the OPCW made after the Second Review Conference to the annual proficiency testing that designated laboratories must undergo to keep their certification. The modified test format now accurately reflects samples that might be submitted for offsite analysis and addresses the concerns raised previously by the SAB. The Board however emphasises that the logistics of offsite analysis—sending chemical weapons samples from an inspection anywhere in the world to designated laboratories whilst maintaining full chain of custody—should be exercised by the OPCW more regularly.

14. Another area of sampling and analysis is the analysis of biomedical samples. The Convention stipulates that for an investigation of alleged use, samples should be collected from human and animal casualties. The OPCW has conducted three confidence-building exercises since the Second Review Conference and worldwide capabilities for biomedical sample analysis have risen significantly. One key issue is criteria for trace level analysis: the target chemicals in biomedical samples may be present only in trace amounts and the evaluation of analysis results for such samples

will require adaptations to the current acceptance criteria that were established for OPCW proficiency testing.

15. Regarding chemical forensics the SAB notes that only a small number of OPCW laboratories have undertaken activities in this area. The capability to identify attribution signatures to connect a toxic chemical or precursor to a particular source or production route has so far not been a focus of OPCW offsite analysis. In the view of the SAB extensive collaboration between institutions would be required to establish such a capability for the OPCW.

16. The SAB concludes that maintaining the designated laboratory network for off-site analysis has been successful, but is costly as well as resource intensive. Considering the developments raised in the four paragraphs above, the Board recommends a comprehensive review of the system to allow for an adaptation to new requirements and to ensure the OPCW's off-site analysis capability remains effective.

Assistance and protection

17. Research is advancing in all areas of chemical defence but development and acceptance of robust and fieldable new methods and devices is generally slow. While there have been advances in relation to assistance and protection against chemical weapons, many challenges still remain. In addition to traditional developments, the last decade has seen a focus on first responder equipment. Because of an increasing concern that non-State actors may employ toxic chemicals, additional technical challenges have arisen in relation to detection, medical countermeasures, and decontamination.

18. The first line of defence against chemical weapons is detection, whereas depending on the measuring objective a device must have different characteristics (to warn of a toxic hazard, identify the chemical, monitor the extent of contamination, check the adequacy of decontamination, etc.). Detectors have generally become smaller and more selective and sensitive in the detection of toxic chemicals but there is still room for improvements in this regard as well as in ease of operation.

19. Developments in the field of medical countermeasures against nerve agents have been slow in the search of a broad spectrum reactivator of nerve agent inhibited acetylcholinesterase. An alternative approach has been the use of a scavenger to detoxify the nerve agent before it reaches its biochemical target, for which different methods have been investigated.

20. Improvements have been sought in physical protection against chemical warfare agents, notably in protective suits and respirators that exert lower physiological stress and which utilise nanomaterials for enhanced protection. New formulations for decontaminants have been tested, including the use of enzymes for detoxification. However, there is limited knowledge available regarding the efficacy of methods for the decontamination of public urban environments, and systems and technologies developed for military use are not always fully transferable. The SAB recommends sharing of best practices in the protection against chemical weapons as part of OPCW international cooperation and assistance activities.

Education and outreach in science and technology

21. Education and outreach in science and technology is important to the Convention's future implementation. In the view of the SAB it is a critical element in preventing the re-emergence of chemical weapons and the misuse of toxic chemicals. Education and outreach serves a number of purposes, such as raising awareness about the Convention among the global scientific community, relevant industry, as well as civil society. The SAB stresses the importance of targeting professional bodies and academic institutions and recommends that outreach activities should consider the particular requirements of a region. The SAB furthermore recommends that education and outreach should be strengthened in the national implementation of the Convention through concerted partnership efforts by all stakeholders, coordinated and supported

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