

**REPORT OF THE SCIENTIFIC ADVISORY BOARD
AT ITS THIRTY-FOURTH SESSION****1. AGENDA ITEM ONE – Opening of the session**

- 1.1 The Scientific Advisory Board (SAB) met for its Thirty-Fourth Session from 15 to 17 March 2022. The session was chaired by Mr Günter Povoden, with Dr Andrea Leisewitz serving as Vice-Chairperson.
- 1.2 Mr Povoden opened the Thirty-Fourth Session of the SAB by welcoming SAB members to the first session of 2022, in particular the six new members of the Board: Professor Elisa Souza Orth of Brazil, Professor Ines Primožič of Croatia, Dr Matteo Guidotti of Italy, Mr Raza Ellahi of Pakistan, Dr Crister Åstot of Sweden, and Dr Robert Kristovich of the United States of America. He noted that 2022 will be a particularly challenging but rewarding year, as the SAB finalises its Report on Developments in Science and Technology for the upcoming Fifth Review Conference (hereinafter “Scientific Report”).¹ The SAB Chairperson also emphasised that the Board always maintains impartiality and neutrality in its work and advice, and aims to deliver scientifically and technically sound reports without any external biases.

Executive summary

- 1.3 Due to the COVID-19 pandemic, this SAB meeting was conducted in a virtual format with simultaneous interpretation provided.
- 1.4 The session focused on hearing from external experts, as well as internal SAB discussions on its ongoing activities. The Board heard from four external speakers. Dr Simon Ovenden and Prof Hongmei Wang shared their research on chemical forensics of chemical warfare agents and their precursors to identify chemical attribution signatures. Prof Hasan Bagheri described his group’s research on novel sensor systems for the detection and identification of pesticides. Mr Kolja Brockmann gave a presentation on the current maturity of additive manufacturing techniques and the dual-use risks they present. In addition, the Board received updates from the Technical Secretariat (hereinafter “the Secretariat”) on Inspectorate Division activities, as well as other activities at the OPCW that concern the Board. Lastly, the Board spent time discussing and deliberating on the ongoing preparations of its Report on Developments in Science and Technology for the Fifth Review Conference, recommending scientific activities to be considered for the Centre for Chemistry and Technology (ChemTech Centre), as well as other ongoing activities.

¹ The Fifth Conference of the States Parties to Review the Operation of the Chemical Weapons Convention.



2. AGENDA ITEM TWO – Adoption of the agenda

The SAB adopted the following agenda for its Thirty-Fourth Session:²

1. Opening of the session
2. Adoption of the agenda
3. *Tour de table*
4. Establishment of a drafting committee
5. Welcome address by H.E. Ms Odette Melono
6. Updates from the OPCW Technical Secretariat
 - (a) Overview of developments at the OPCW since the last session of the Scientific Advisory Board
 - (b) Update on OPCW Inspectorate Division activities
7. Centre for Chemistry and Technology brainstorming session
8. Studies of chemical attribution signatures of VX
9. Additive manufacturing: chemical weapon proliferation risks and export control challenges
10. A study on the forensic signature(s) of the chemical weapon precursor DMPADC³
11. Colorimetric paper-based sensor arrays for the simultaneous detection and determination of pesticides
12. Updates on Scientific Advisory Board-related business
 - (a) Fifth Review Conference updates and discussion
 - (b) Updates on topical workshops organised by the Scientific Advisory Board
 - (c) Consideration of scientific topics for Scientific Advisory Board publication
13. Any other business and closing remarks
14. Adoption of the report
15. Closure of the session

² It should be noted that while presentations and agenda items are grouped in this report based on topic matter, they were not always presented sequentially as listed due to scheduling considerations of the presenters and other timing restraints.

³ DMPADC is the abbreviation used for N,N-dimethylphosphoramidic dichloride, a key precursor for the nerve agent Tabun.

3. AGENDA ITEM THREE – *Tour de table*

The Chairperson invited all Board members to briefly introduce themselves, starting with the six new members of the Board.

4. AGENDA ITEM FOUR – Establishment of a drafting committee

The Chairperson called for volunteers who wished to be part of the drafting committee to notify the SAB Chairperson, Vice-Chairperson, or Secretary accordingly.

5. AGENDA ITEM FIVE – Welcome address by H.E. Ms Odette Melono

- 5.1 The Deputy Director-General of the OPCW Secretariat, H.E. Ms Odette Melono, welcomed everyone to the Thirty-Fourth Session of the Board on behalf of the Director-General, Ambassador Fernando Arias, conveying his well wishes and his hope to meet with the SAB members as soon as the situation permits. She congratulated the new members on their appointment and acknowledged the Board's professionalism and dedication over the past two challenging years.
- 5.2 The Deputy Director-General reported that the OPCW is continuing to make significant progress in upgrading the OPCW Laboratory into a Centre for Chemistry and Technology (ChemTech Centre), which will become an important tool to support the mission and work of the Organisation. The construction of the ChemTech Centre is on track to be completed by the end of this calendar year, at which point the OPCW Laboratory and Equipment Store will begin to move its base of operations to the Centre. With the construction phase well under way, the Secretariat has turned its attention to the activities that will take place at the Centre and is looking forward to the SAB's recommendations in that respect. A recently released Note by the Secretariat to States Parties outlines some of the anticipated programmes and activities that will take place at the ChemTech Centre. These activities will help the OPCW more effectively prevent and respond to chemical weapons use, and support peaceful uses of chemistry. She further noted that the recommendations from the SAB's Temporary Working Group (TWG) on the analysis of biotoxins will be very helpful in defining some of the forward-looking scientific activities that could take place at the ChemTech Centre.
- 5.3 The Deputy Director-General then highlighted the decision that States Parties adopted at the Twenty-Sixth Conference of the States Parties (hereinafter "the Conference") entitled "Understanding Regarding the Aerosolised Use of Central Nervous System-Acting Chemicals for Law Enforcement Purposes" (C-26/DEC.10, dated 1 December 2021). Through this decision, the Conference understands that the use of aerosolised central nervous system-acting chemicals (CNS-acting chemicals) is inconsistent with law enforcement purposes as a purpose not prohibited under the Convention. Noting that the SAB's extensive work in this area is explicitly recognised in the decision, she reminded the Board that the decision also requests the SAB to continue to review relevant developments in science and technology related to CNS-acting chemicals and provide updates to the Conference, as appropriate.
- 5.4 Recalling that the upcoming Fifth Review Conference will take place in The Hague in May 2023, the Deputy Director-General stressed the importance of preparing the SAB's Scientific Report well ahead of the Fifth Review Conference, so that States Parties can fully profit from having an independent analysis of science and technology trends of relevance to the Chemical Weapons Convention (hereinafter "the Convention").

5.5 In conclusion, the Deputy Director-General expressed appreciation to the Board members for their dedicated work, stating that the OPCW clearly benefits from their wealth of experience and scientific expertise. In that respect, she concluded by noting that the Board's advice in the post-destruction phase and for heightened non-proliferation efforts in the future will be more vital than ever before.

6. AGENDA ITEM SIX – Updates from the OPCW Technical Secretariat

6.1 Several Secretariat staff members provided updates on ongoing Secretariat activities. The SAB Secretary gave the Board an overview of overarching developments at the OPCW that are of relevance to the SAB's work. A representative from the Inspectorate Division gave an update on Article IV and VI inspections, with a focus on sampling and analysis activities.

Subitem 6(a): Overview of developments at the OPCW since the last session of the Scientific Advisory Board

6.2 The SAB Secretary briefed the Board on relevant developments at the OPCW since its Thirty-Third Session, noting first the finalisation of the session report (SAB-33/1, dated 18 November 2021), and the response thereto of the Director-General (EC-99/DG.16, dated 2 March 2022). In addition, the report of the third meeting of the TWG on the analysis of biotoxins was also published on the OPCW website (SAB-33/WP.2, dated 14 February 2022).

6.3 Turning to the Twenty-Sixth Conference, the SAB Secretary further elaborated on the decision adopted on CNS-acting chemicals (C-26/DEC.10). He recalled that the SAB has a long history (almost 20 years) of providing advice on this particular topic and has considered CNS-acting chemicals at different SAB sessions, in scientific reports for review conferences, and at various side events and briefings. He further provided a summary of the SAB's advice on CNS-acting chemicals. This includes the SAB's prior determination that CNS-acting chemicals are toxic chemicals and should not be considered riot control agents; this determination was issued by the SAB in an extensive report on riot control agents entitled "Response to the Director-General's Request to the Scientific Advisory Board to Provide Consideration on Which Riot Control Agents Are Subject to Declaration Under the Chemical Weapons Convention" (SAB-25/WP.1, dated 27 March 2017). Some CNS-acting chemicals are as lethal as nerve agents and their dose cannot be controlled in aerosol form. He concluded that while the Board stated in its Scientific Report for the Fourth Review Conference in 2018 that it sees no value in revisiting this topic, as scientific facts remain unchanged, the recent decision in fact asks the Board to continue to monitor this area.

6.4 When considering CNS-acting compounds, the Board noted the importance of not just monitoring the developments in the compounds themselves, but also the potential means by which they may be dispersed. They noted that this may be an area that warrants further consideration. The SAB Secretary called on Board members to continue to consider which elements of CNS-acting chemicals may need further deliberation.

- 6.5 Continuing with his updates, the SAB Secretary acknowledged the generous contribution of EUR 70,000 made by the Russian Federation to the SAB Trust Fund in December 2021.⁴ The Trust Fund supports those SAB activities for which no funding is allocated in the Programme and Budget, such as the work of the SAB's temporary working groups or topical workshops.
- 6.6 Lastly, concerning the dates of the next SAB session (SAB-35), the SAB Secretary noted that the pandemic continues to create uncertainty for potential in-person meetings. However, it is hoped that the SAB will be able to meet in person twice in 2022—once in the early summer and another time in the fall—before its Scientific Report for the Fifth Review Conference is due.

Subitem 6(b): Update on OPCW Inspectorate Division activities

- 6.7 Dr Jo-Anne Rasmussen (Analytical Chemist Inspector, OPCW) provided an update on some of the sampling and analysis missions that the OPCW has conducted over the past few years. She recalled the relevant provisions of the Convention related to sample collection and handling, as well as on-site and off-site analysis.
- 6.8 Sampling and analysis is incorporated in almost all OPCW missions, including at: chemical weapons destruction facilities (CWDFs) and chemical weapons storage facilities (CWSFs) where they verify the agent(s) present and perform monitoring work; chemical weapons production facilities (CWPFs) where they verify the type of agent; industry missions involving scheduled chemicals and other chemical production facilities (OCPFs), where they verify the absence of undeclared scheduled chemicals (except for Schedule 1); technical assistance visits, depending on the mandate of the visit; challenge inspections, depending on the challenge; and investigations of alleged use, depending on the parameters of the investigation. It is important to note that, to date, no challenge inspections or investigations of alleged use have been conducted.
- 6.9 Dr Rasmussen provided an update on the chemical weapons destruction activities at Article IV facilities, noting that all the sampling and analysis is conducted by the site with OPCW inspectors acting as witnesses. Turning to Article VI (Industry) inspections, she noted that since 1997, the number of Article VI missions has been consistent at 241 per year, with significantly lower numbers achieved over the past two years due to the COVID-19 pandemic. Of those inspections, they have conducted an average of 10 sampling and analysis missions per year since 2009, though none were conducted in the past two years, and none have ever been conducted for Schedule 1 chemicals. In fact, an exercise meant to simulate a sampling and analysis mission was recently conducted in order to ensure that inspectors are able to maintain their expertise and train appropriately in anticipation of restarting these missions in the near future.
- 6.10 Sampling is conducted, per agreement, either by the State Party or an OPCW inspector, although the OPCW always provides the required equipment. Different types of samples are collected, ranging from neat agents and product mixtures to waste, water or effluent, and environmental samples depending on the type of industry and type of processes used by the facilities. The aim is to choose the samples that will yield the most information about the plant and processes, since the objective of sampling and analysis is to determine if there are any undeclared chemicals present.

⁴ See: <https://www.opcw.org/media-centre/news/2021/12/russian-federation-contributes-eu70000-trust-fund-opcws-scientific>.

- 6.11 The Inspectorate Division has recently been working on the acquisition of new sampling and analysis kits. The current kits are heavy and can only be transported via cargo (compared to the more preferential hand-carry means). By incorporating new equipment and removing redundant or outmoded equipment, as well as adopting a semi-modular approach, they would be able to reduce the kits from just over 300 kg down to approximately 120 kg, thereby making them easier to transport.
- 6.12 Upon being asked to further elaborate on the new sampling and analysis kits, Dr Rasmussen explained that the kit includes only sample collection and preparation equipment. Other components such as benchtops are not included. She also noted that though they are looking into smaller, lighter equipment, they do not want to compromise on quality.
- 6.13 The Board then asked if inspectors also look for precursors of scheduled chemicals during industry inspections. Dr Rasmussen replied that they are primarily focused on looking for any undeclared scheduled chemical. The OPCW software is designed such that it only looks for chemicals contained in the OPCW Central Analytical Database (OCAD). Chemicals that are not listed in the OCAD are considered outside the purview of OPCW inspections. If there are no hits in the OCAD, they do not conduct any further analysis of the data.
- 7. AGENDA ITEM SEVEN – Centre for Chemistry and Technology brainstorming session**
- 7.1 The SAB Secretary recalled the previous brainstorming session on the ChemTech Centre during the Thirty-Third Session of the SAB. He briefly provided an overview of the enhancements that the facility will afford the OPCW over the current laboratory and store, and reminded the Board of some of their suggestions and recommendations on potential scientific activities from the prior SAB session. He noted that some of the ideas had already been considered by the Secretariat and were mentioned in the recently issued Note S/2034/2022, dated 1 March 2022, which has been distributed to States Parties.
- 7.2 The floor was then opened for additional suggestions and comments from the Board. After a robust discussion, the SAB Secretary noted that he would amend the list of ideas to reflect the discussion held at the Thirty-Fourth Session and distribute this among the members for their thoughts and comments. A consensus-driven document will then be provided to the Director-General for his consideration.
- 8. AGENDA ITEM EIGHT – Studies of chemical attribution signatures of VX**
- 8.1 Dr Simon Ovenden (Department of Defence – Defence Science and Technology Group, Australia) opened his presentation with a brief introduction and an overview of the Defence Science and Technology Group (DSTG) within Australia’s Department of Defence. It is made up of nine divisions, including a Land Division with strong capabilities in chemical and biological defence. The DSTG is the only Schedule 1 facility in the country, and Australia’s only OPCW designated laboratory that handles both environmental and biomedical samples.

- 8.2 Dr Ovenden briefly touched upon some of the past and ongoing work that the DSTG has done related to chemical attribution, including ricin provenance attribution, impurity profiling of various chemical weapon agents, and identification of the chemical attribution signatures (CAS) of fentanyl syntheses for route attribution. He noted that many of these results have been published in open scientific literature.
- 8.3 Three stocks of VX were analysed for impurity and degradation products to further understand the chemical profile of VX, and to aid in the identification of potential CAS.⁵ The three VX stocks analysed were synthesised in 2014, 2017, and 2018 using the same synthetic method, allowing for a better understanding of their chemical profile over time. Precursor chemicals were all purchased from the same manufacturer. While liquid chromatography (LC) and gas chromatography (GC), coupled to mass spectrometry (MS), were the main analytical techniques used, other techniques were used as well, such as nuclear magnetic resonance (NMR) spectroscopy, and various MS methods. A total of 44 impurities were identified, 24 of which were present in all three agent stocks, while 37 were readily identified through accurate mass measurement, as well as matches with the National Institute of Standards and Technology and the OCAD library. Several compounds identified in minor amounts could be traced back to impurities in the precursor compounds used in the synthesis of VX, and hence may be useful as CAS for source attribution. Two of these were linked to an impurity in 2(diisopropylamino)ethyl chloride, and one was linked to residual phosphorus trichloride in methyldichlorophosphine.
- 8.4 The initial results spurred further scientific questions of interest to the research team—for instance: could different synthetic routes for VX be differentiated based on the impurities present? They then prepared VX via four different synthetic routes, each repeated six times, and each of these sampled three times (72 total samples). These were then each analysed through LC-MS, GC-MS, and NMR. The collected data were subjected to multivariate analysis in order to identify the most important variables, and 73 CAS were identified across the four synthesis methods. In addition, the group is allowing the VX samples to age so it can see what changes might occur to the CAS over time. Initial results indicate that each of the four synthesis methods have discrete variables specific to them, suggesting that samples of VX can in fact be differentiated based on their method of synthesis, though Dr Ovenden reminded the Board that there is still more research to be done before conclusions are finalised.
- 8.5 Dr Ovenden summarised his presentation by suggesting that while identifying CAS is interesting and potentially very useful, often the total impurity profile can be more informative for understanding a given sample's history.
- 8.6 The Board had several questions for Dr Ovenden, first asking to what extent his team's initial research was useful when continuing and expanding its studies on VX. Dr Ovenden replied that it was quite useful, though the work is still ongoing. The research team tried to identify similarities that could be applied from their first project to their second, including the methods that were used. A follow-up query asked whether they switched to targeted data analysis once they were presented with many more samples in their second study. Dr Ovenden replied that all their analyses were

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SPB Ovenden, RL Webster et al. "The identification of chemical attribution signatures of stored VX nerve agents using NMR, GC-MS, and LC-HRMS." *Talanta*. 2020 May 1;211:120753.

untargeted to begin with, as they did not know what they would be looking for. They started with background work on existing agent VX samples and had to see what was important in the second batch of work. Unfortunately, they did not have certain MS equipment that could have simplified their approach.

- 8.7 Dr Ovenden was then asked whether any data was collected on the commercial chemicals used by the research group in the synthesis of their VX samples. It could be interesting to see which impurities may already be present, or whether different brands had similar chemical profiles. Dr Ovenden confirmed that they are looking into other sources of precursor chemicals to see how this may change the chemical profiles of synthesised VX.
- 8.8 A follow-up question asked whether plant DNA present in a sample could be used to obtain information on where the plant came from, and if the team had thought of combining this with protein-related analysis methods—for example to determine the origins of a ricin sample. Dr Ovenden confirmed that they have actively studied the epigenetics of castor beans and are looking to tie that information to metabolomics work.
- 8.9 The Board then asked Dr Ovenden about some of the identified chemical species they had found, noting the identification of several trisulfides, and whether these were common species. Dr Ovenden commented that thiols are very reactive and, recalling previous work related to sulfur mustard, it is not unexpected to see exotic sulfur species.

9. AGENDA ITEM NINE – Additive manufacturing: chemical weapons proliferation risks and export control challenges

- 9.1 Mr Kolja Brockmann (Stockholm International Peace Research Institute, Sweden) briefed the Board on the impact of additive manufacturing on weapons proliferation and export controls. While ‘emerging technologies’ have recently come to the attention of many arms-control, non-proliferation, and disarmament forums, their actual capabilities and versatility of applications are often overestimated, including the potential risks they may pose. Export control has been identified as a means to help safeguard transfers of dual-use goods and technology. All States are required to operate appropriate export control systems in line with United Nations Security Council resolution 1540. Control lists related to dual-use chemical and biological materials also exist, and there are also the ‘catch-all’ controls that can be used for non-listed items of dual-use concern. Export control is only one piece of a comprehensive approach to reducing the risk of the re-emergence of chemical weapons. He noted that additive manufacturing illustrates many of the same challenges experienced with other emerging technologies.
- 9.2 Turning to additive manufacturing, Mr Brockmann underlined that it is an area comprised of different automated production techniques, rather than one specific technology. He explained that additive manufacturing can produce objects of virtually any shape or form through the deposition and fusing of successive layers of material together using a variety of techniques, such as heat-liquefied extrusion, inkjet printing, stereolithography, sintering, and laser or electron beam melting. An increasing variety of materials can be used, including polymers, resins, metal powders, ‘bioinks’, and many more.
- 9.3 Mr Brockmann remarked that additive manufacturing can potentially decentralise production capabilities, reduce the necessity for physical transportation of goods, and bring production to the end user. This is an important consideration in export control, as the opportunity to interdict dual-use goods at national borders is decreased. He noted that

there is an increasing trend to use intangible technology transfers versus physical cross-border transfers. The lack of a physical item that needs to cross through some type of control point (like customs) makes proper tracking, licensing, and enforcement related to intangible technology transfers difficult—and this is especially true for additive manufacturing technologies. There are few existing import and export controls specifically tailored to additive manufacturing.

- 9.4 With regard to chemical weapons proliferation risks, there are several areas of concern when it comes to the use of additive manufacturing: the production of equipment, the printing of live tissues, and the manufacture of delivery systems and their components.
- 9.5 Additive manufacturing can be used to print a range of specific parts for production and laboratory equipment, as well as other items relevant to the production of chemical or biological weapons. Mr Brockmann noted that there is a lot of research being conducted on the additive manufacturing of chemical (micro-)reactors with varying geometric complexities, tolerances, and chemically active surfaces that could be combined with continuous flow production techniques. In this way, additive manufacturing could be used to help conceal a clandestine chemical synthesis laboratory. However, chemical compatibility and resistance limit the types of syntheses that can be done in this way. Moreover, there has been limited testing of the relevant properties of printed parts and equipment. Therefore, while additive manufacturing may offer an alternative production pathway for certain dual-use materials, it may involve additional hurdles—technical, knowledge-based, or in-process development—that would not justify the effort.
- 9.6 While there are many positive applications of bioprinting in medicine, the printing of tissue or organelles for the purpose of pharmacological testing is potentially also relevant in the context of the development of biological or chemical weapons. Bioprinted tissue could be used to assess specific interactions between chemical or biological agents and certain tissue types under conditions that are otherwise difficult to simulate. However, these techniques are not uniquely enabling; established methods, such as animal testing, are currently more accessible and require a more common set of skills. The potential misuse of additive manufacturing for bioprinting should be monitored, but it is likely not an immediate risk in this context.
- 9.7 In recent years, there has been interest and progress in the use of additive manufacturing of delivery systems and their components. The use of additive manufacturing to produce parts or components of drones means that their designs can be adapted to increase their capabilities and make them more suitable for use as a delivery system for threat materials. Plans and build files for printable parts of drones are commonly exchanged in the do-it-yourself community, and these may provide an attractive option for non-State actors. Additionally, other components that might be put on a drone, like spray tanks or nozzles, may also be created with additive manufacturing.
- 9.8 In conclusion, Mr Brockmann noted a highly nuanced risk scenario around additive manufacturing. Additive manufacturing does not deliver specialised high-end products ‘at the touch of a button’, but rather involves a process in which different stages require a variety of skills. While the capabilities of additive manufacturing are advancing rapidly, particularly in relation to metal printing, there are only limited and very specific applications for additive manufacturing in the chemical weapons context. Proliferation scenarios involving additive manufacturing are highly dependent on threat actors and

specific circumstances. But continued monitoring of technological developments is critical. In addition, there should be an ongoing review of relevant treaties and export control regimes, amendments should be made to control lists as applicable, export control implementation should be strengthened, and targeted outreach and awareness campaigns should be carried out for key stakeholders, as should the promotion of responsible innovation in research and development to strengthen compliance procedures in industry and research institutes.

- 9.9 The Board agreed that while certainly advancing, the current state of additive manufacturing does not constitute an imminent threat in the chemical and biological weapons space. However, continued monitoring of this rapidly maturing field is warranted in order to be prepared for any potential dual-use concerns.
- 9.10 The Board also noted that there is a lack of clear regulations and guidelines governing export control of additive manufacturing products, ultimately leaving it to individual companies to make decisions on a case-to-case basis in line with their internal codes of conduct and ethical standards. Mr Brockmann concurred with this point, and reiterated that it currently comes down to overlaps where, for instance, components or certain applications may be covered incidentally due to other proliferation risks; for example, lasers used in additive manufacturing machines may be subject to controls based on potential uses in conventional weapons. This is one of the topics where different regimes have communicated regularly among themselves, but across-the-board solutions have yet to be adopted.
- 10. AGENDA ITEM TEN – A study on the forensic signature(s) of the chemical weapon precursor DMPADC**
- 10.1 Prof Hongmei Wang (State Key Laboratory of NBC Protection for Civilians, China) shared a study that her research group conducted on detecting and identifying forensic signatures of the chemical weapon precursor N,N-dimethylphosphoramidic dichloride (DMPADC), a key precursor for the nerve agent Tabun. She began by giving an overview of the field of chemical forensics, noting the importance of CAS in the determination of the origins of chemical warfare agents.
- 10.2 She then turned to the focus of her presentation. Detailed descriptions of three different synthetic routes to make DMPADC were shown, followed by information related to the precursor chemicals used for each. Both GC-MS and NMR were used in the analysis of the samples, and chemometric methods were then used to help find and identify the CAS for each synthetic route. Twenty potential CAS were identified, with structures assigned to five of them. A partial least squares discriminant analysis (PLS-DA) model was then developed to discriminate and classify the synthetic samples. The model was able to distinguish between the synthetic routes, and Prof Wang noted that incorporating data from additional DMPADC samples from different sources would only improve the model further.
- 10.3 The Board asked whether there were plans to further characterise the identified CAS, including whether any stability studies were planned. Prof Wang explained that although they did not carry out any long-term stability tests as part of their study, the samples and their constituents did prove to be stable for a month.

11. AGENDA ITEM ELEVEN – Colorimetric paper-based sensor arrays for the simultaneous detection and determination of pesticides

- 11.1 Prof Hasan Bagheri (Baqiyatallah University of Medical Sciences, Islamic Republic of Iran) presented on his group's research into the use of colorimetric paper-based sensor arrays for the detection and determination of pesticides. He gave an overview of sensors and the different existing methods for detecting and identifying pesticides before addressing the most recent research in detail.
- 11.2 The research group wanted to design a new colorimetric paper-based sensor for the rapid monitoring of six major organophosphate and carbamate pesticides: carbaryl, paraoxon, parathion, malathion, diazinon, and chlorpyrifos. Gold and silver nanoparticles were modified with different stabilising agents and incorporated onto a paper substrate. Depending on the stabilising agent used, interaction between a given pesticide and stabilised nanoparticle would result in a visible colour change that could be measured. This is due to either the aggregation of nanoparticles, changes in their surface characteristics, or both. By creating an array of differently stabilised nanoparticles, a pattern of colour change (which can be quantitated with a digital camera) is indicative of the presence of a certain amount of a given pesticide. Repeated experiments showed that the six aforementioned pesticides could be differentiated, and their quantities detected, when introduced to the sensor arrays in liquid form. In addition, detection was successfully performed on real-life samples where the pesticides were in common matrices, such as tap water, apple juice, or rice.
- 11.3 The research group then wanted to test the sensor's ability to detect and differentiate between pesticides in the vapour or aerosol phase. Arrays of six sensor areas on paper were made, and these were placed at the end of a closed container where vapours and aerosols could be introduced. The sensor arrays provided selective responses to thion pesticides such as malathion, parathion, chlorpyrifos, and diazinon. The sensing assay could also differentiate between aliphatic and aromatic thions, and further discriminate amine-containing compounds from the other studied analytes. Multivariate statistical methods confirmed the results. The sensor arrays are also capable of low-level detection, with detection limits of 58, 103, 81, and 117 ng/mL determined for malathion, parathion, chlorpyrifos, and diazinon, respectively. Moreover, the array could be employed to analyse four studied pesticides simultaneously.
- 11.4 Prof Bagheri concluded by summarising the results and remarking that the research group hopes their technology can be useful in real-world applications, perhaps by being embedded in the masks or clothes of farmers to act as a diagnosis kit to monitor pesticide exposure, or in food quality laboratories, or even food packaging, where commonly used pesticide contamination could be detected inexpensively at a large scale.
- 11.5 The Board asked how much exposure time is needed to get a measurable colour response. They also queried whether the sensor media were reversible in nature—i.e., if they could be used multiple times. Prof Bagheri noted that when using these sensor media as an electronic tongue (when samples are introduced to the sensor media as liquids), the required exposure time can be quite short. However, when using the sensor arrays as an electronic nose (when samples are introduced as vapours or aerosols), the time of required exposure can be several hours. As for reversibility, these sensors are single-use only.

11.6 The Board then asked about temperature sensitivity, and if the research group had tested these sensors under various temperatures, noting the importance for detectors to work in variable environmental conditions in real-life applications. Prof Bagheri confirmed that the group had tested under a wide range of temperatures (15 to 45 °C). The sensors performed well as long as the humidity was low; if the humidity was too high, it started to interfere with sensor response.

12. AGENDA ITEM TWELVE – Updates on Scientific Advisory Board-related business

12.1 The Board dedicated some time to discussing the ongoing preparation of its Scientific Report in support of the Fifth Review Conference, and providing updates on several planned workshops scheduled for the months ahead. This was important considering that this session was the first for six new Board members.

Subitem 12(a): Fifth Review Conference updates and discussion

12.2 The SAB Secretary provided an overview of the content and schedule of preparations for the Board's Scientific Report for the Fifth Review Conference and reminded the Board of the subgroups and their topical areas of focus. He also outlined the changes in the subgroup compositions given the six new Board members. With the Fifth Review Conference scheduled for May 2023, the SAB's Scientific Report should be finalised by November 2022.

12.3 The Board went through the updates of the seven different subgroups and provided feedback. The SAB Chairperson remarked on the substantial progress and urged his colleagues to maintain their momentum. He also asked that the subgroups report on any existing gaps in their work so that appropriate technical experts can be invited for the next SAB meeting.

Subitem 12(b): Updates on topical workshops organised by the Scientific Advisory Board

12.4 Dr Becker-Arnold and Prof Razia began by providing an overview of the current situation and planning for the SAB's planned joint workshop with the chemical industry. The dates have been fixed for 20 – 21 June in Antwerp at BASF's chemical production site, and will include a tour of the facility. It is planned as a small workshop for 20 – 25 participants. The next step is to identify the number of presentations that can fit in the programme and identify available speakers.

12.5 They noted recent discussions with contacts at the European Chemical Industry Council and the International Council of Chemical Associations to see how they might want to contribute to the workshop. While the agenda is still in preparation and will depend heavily on the speakers available, the workshop will likely cover topics such as green chemistry, sustainability, circular economy, cybersecurity, and overarching innovation in the chemical industry.

12.6 The SAB Secretary thanked both Dr Becker-Arnold and Prof Razia for their patience and determination in planning this workshop, as it is extremely valuable for the SAB and the upcoming Scientific Report. In conclusion, the SAB Secretary invited any Board members who may be interested in participating in the workshop to inform him, the SAB Chairperson, or the SAB Vice-Chairperson.

- 12.7 The SAB Secretary then presented the updates on the other planned workshop, which is being organised in partnership with the International Union of Pure and Applied Chemistry (IUPAC), on Prof Saeed's behalf due to Internet instability.
- 12.8 The SAB Secretary recalled that in addition to the industry workshop, there are plans to hold a SAB-IUPAC workshop focused on artificial intelligence (AI) applications in chemistry. The idea for this workshop came as a recommendation from the SAB at its Thirty-Second Session. The use of AI in chemistry is an important emerging field that warrants further consideration by the Board, especially in relation to the upcoming Review Conference. In the past, the SAB and IUPAC have collaborated on topical events in support of review conferences, and this workshop will be organised in a similar way.
- 12.9 The SAB plans to hold the workshop on AI applications in chemistry in The Hague in June, directly preceding the Thirty-Fifth Session of the SAB. The provisional agenda includes six plenary and two break-out sessions spread over two-and-a-half days. While the agenda is still in preparation, some topics include the implications of AI in chemistry for the OPCW and IUPAC, use of AI in synthetic design, robotics and automation, and the ethical implications of AI technology. The aim is to have several SAB members involved to facilitate discussions and help record and distil the information shared at the workshop for inclusion in its Scientific Report for the Fifth Review Conference.
- 12.10 During the discussion, it was noted that interesting research is being done on the use of AI to provide real-time monitoring and modification of reaction conditions in chemical destruction processes. It was agreed that this topic would be suitable for inclusion in the workshop if the appropriate speaker could be found. The SAB Secretary ended the discussion by encouraging interested SAB members to reach out if they would like to participate in the joint SAB-IUPAC workshop.

Subitem 12(c): Consideration of scientific topics for Scientific Advisory Board publication

- 12.11 The SAB Secretary provided a brief overview of how the Board decides when and on what topics it seeks to generate and submit manuscripts for publication in scientific literature. Prof Ghanei opened his presentation by recalling that the SAB provides pure and unbiased scientific insight and advice on technical matters, and that Board members serve in their individual capacity with no State-related motivation or interests involved. SAB publications should be peer reviewed and available to be referenced by other scientists around the world. Prof Ghanei provided a brief overview of some previous SAB publications and suggested that the SAB should continue to publish, and noted that it would be useful to have some guiding principles on the matter to rule out any misunderstandings. He went through several topics for continued SAB consideration.
- 12.12 The SAB Chairperson agreed that it is important for the SAB to publish its work, as appropriate, in peer-reviewed scientific journals. The Board raised a few additional topics that may be considered for publication in addition to the ones presented by Prof Ghanei.
- 12.13 The SAB Secretary invited Board members to send an email with any other comments on this topic to himself, the Chairperson, and the Vice-Chairperson, or the entire Board, as appropriate.

13. AGENDA ITEM THIRTEEN – Any other business and closing remarks

13.1 The SAB Chairperson thanked the staff of the Secretariat and the interpretation team for their support for this successful session and noted that he was looking forward to the next in-person meeting. He then thanked all the members for their participation in and contribution to the SAB's Thirty-Fourth Session.

13.2 The SAB is grateful for the voluntary contributions made to support its work, and expresses its thanks to the European Union for its April 2019 Council decision, which provides funding for TWGs.

14. AGENDA ITEM FOURTEEN – Adoption of the report

The SAB agreed to adopt the report for its Thirty-Fourth Session via correspondence after the session.

15. AGENDA ITEM FIFTEEN – Closure of the session

The Chairperson closed the Session at 15:40 CET on 17 March 2022.

Annex: List of Participants in the Thirty-Fourth Session of the Scientific Advisory Board

Annex

**LIST OF PARTICIPANTS IN THE THIRTY-FOURTH SESSION
OF THE SCIENTIFIC ADVISORY BOARD**

	Participant	Institution
Members of the Scientific Advisory Board		
1.	Dr Crister Åstot	Swedish Defence Research Agency (FOI), Sweden
2.	Dr Khaldoun Bachari	Algerian Public Scientific and Technical Research Centre in the Physico-Chemical-CRAPC, Algeria
3.	Dr Renate Becker-Arnold	BASF, Germany
4.	Dr Elma Biscotti	Scientific and Technical Research Institute for Defense, Argentina
5.	Dr Anne Bossée	DGA CBRN Défense, France
6.	Prof Vladimir Dimitrov	Institute of Organic Chemistry with Centre of Phytochemistry, Bulgarian Academy of Sciences, Bulgaria
7.	Mr Raza Ellahi	Defence Science & Technology Organization (DESTO), Pakistan
8.	Prof Mostafa Ghanei, MD	Baqiyatallah University of Medical Sciences, Iran (Islamic Republic of)
9.	Dr Norman Govan	Defence Science and Technology Laboratory, United Kingdom of Great Britain and Northern Ireland
10.	Dr Matteo Guidotti	Institute of Chemical Sciences and Technology Institute (SCITEC) of the Italian National Research Council, Italy
11.	Prof Victor Kholstov	Ministry of Industry and Trade, “GosNIIOKhT”, Russian Federation
12.	Dr Robert Kristovich	United States Army DEVCOM Chemical Biological Center, United States of America
13.	Dr Andrea Leisewitz (Vice-Chairperson)	Universidad San Sebastián, Chile
14.	Prof Imee Su Martinez	University of the Philippines-Diliman, Philippines
15.	Dr Daan Noort	TNO, Rijswijk, Netherlands
16.	Prof Elisa Souza Orth	Federal University of Paraná, Brazil
17.	Mr Günter Povoden (Chairperson)	CBRN Defence Centre, Ministry of Defence, Austria
18.	Prof Ines Primožič	University of Zagreb, Croatia
19.	Prof Syeda Sultana Razia	Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh
20.	Prof Ahmed E. M. Saeed	Sudan University of Science and Technology, Sudan
21.	Dr Yasuo Seto	RIKEN SPring-8 Center, Japan
22.	Dr Maciej Sliwakowski	Lukasiewicz Research Network – Institute of Industrial Organic Chemistry, Poland
23.	Prof Fengxia Sun	Hebei University of Science and Technology, China
24.	Dr Nomandla Magnificent Vela	Protechnik Laboratories, South Africa

Invited Participants		
25.	Prof Hasan Bagheri	Baqiyatallah University of Medical Sciences, Iran (Islamic Republic of)
26.	Mr Kolja Brockmann	Stockholm International Peace Research Institute, Sweden
27.	Dr Craig Cormick (Member of the ABEO)	Independent Consultant, Australia
28.	Dr Graciela Gonzalez (Member of the ABEO)	University of Buenos Aires, Argentina
29.	Dr Simon Ovenden	Department of Defence – Defence Science and Technology Group, Australia
30.	Dr Jo-Anne Rasmussen	Organisation for the Prohibition of Chemical Weapons, Netherlands
31.	Prof Hongmei Wang	State Key Laboratory of NBC Protection for Civilians, China
Secretary to the Scientific Advisory Board		
32.	Dr Peter Hotchkiss	Organisation for the Prohibition of Chemical Weapons, Netherlands