The OPCW Science & Technology Monitor

A sampling of Science & Technology relevant to the Chemical Weapons Convention

9 December 2014 Volume 1, Number 6

Featured Content:

Image from Bay Area on tap 21 January 2012.

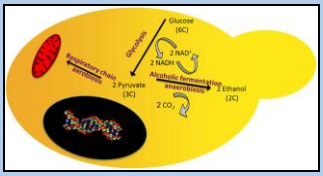

Image from Nature Education, 2010, 3(9):17

Producing chemicals for the bioeconomy with fermentation;

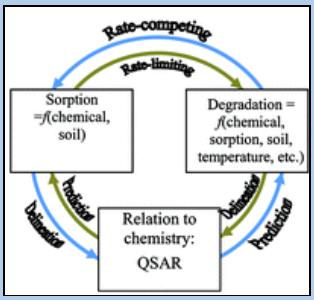

Image from ACS Symposium Series, Vol. 1174, Chapter 1, 1-4.

Environmental fate

Photo from Jelger Herder/Buiten-beeld/Getty (from Nature News 8 August 2014)

Bioaccumulation

Welcome

Welcome to our sixth issue of *The OPCW Science and Technology Monitor*, an occasional bulletin to provide updates on developments in science and technology across a broad spectrum of topics relevant to the CWC.

The S&T Puzzle

We congratulate Marc Blum for recognising that a molecule which is the lowest-energy structure for a certain sum formula is called a "Guinness Molecule". Marc has promised that he will choose a highly informative feature for an upcoming S&T Monitor.

In this issue we would like to know where Maridia is located and what one might find there. The answer is hidden within one of the links.

To the first person to solve the puzzle, we offer your choice of choosing our next featured topic, designing the next puzzle or receiving a gift of a special beverage hand selected by the Science Policy Adviser. Good luck!

In this issue:

News and Updates
Scheduled Chemicals
The Bioeconomy
Science, Technology, Industry and Policy
Environmental Fate

News and Updates

Recently published reports:

Report on the First International Spiez CONVERGENCE Workshop.

EDUCATION AND ENGAGEMENT: Promoting a Culture of Responsible Chemistry; the final report of the Scientific Advisory Board's Temporary Working Group on education and outreach.

German Ethics Council Opinion on Biosecurity.

Photo by Lyle Buss (from Chem & Eng News 3 December 2014)

gut bacteria for environmental remediation

Science Fun:

All this talk of the bioeconomy and fermentation calls out for a closer look at the value of beer!

Beer is far more than a just a beverage, it can stimulate creativity, it can teach us about complex earth science and the importance of proper packaging, it won't get spoiled by fruit flies, it can be brewed spicy hot and it has very interesting chemistry. As an added bonus for those of you who prefer your beer cold, watch this.

Have you ever wanted to climb walls and hang from ceilings? Perhaps you need a pair of gecko gloves? (Read more here). We recommend against consuming beer while using this product.

The answer to the Science Net Links mystery photo linked in our last issue can be found here (see image from AAAS below)

News from other S&T relevant organisations:

The Comprehensive Nuclear Test Ban Treaty Organisation (CTBTO) held an Integrated Field Exercise (IFE14), where they employed a variety of analytical tools for the on-site investigation of a possible nuclear blast. See the CTBTO field blog to follow along with what transpired.

THE PORT held a "hackathon" at the CERN Laboratory to design technology for the day-to-day needs of people living in areas of the planet experiencing conflict or natural disaster (and our colleague Amir Imani from IVB participated). Highlights of the hackathon are available in the 17 November 2014 issue of the *CERN Bulletin*.

The Defence Science and Technology Laboratory (Dstl) of the United Kingdom, a Designated Laboratory, publishes a periodic newsletter, called *Insight*. Issue 24 is now available online.

Making news in chemistry:

From the week of 9-16 November

From the week 17-22 November

From the week 23-29 November

Scheduled Chemicals

The Annex on Chemicals of the Chemical Weapons Convention (CWC) provides guidelines that articulate criteria for categorising chemicals into three Schedules. These Schedules identify chemicals for application of verification measures. While the Schedules themselves do not define a chemical weapon, they do list chemicals with known relevance to production and/or use of chemical agents. Chemicals, however, have multiple uses and there are many examples of chemicals from all Schedules applied to purposes allowable under the CWC.

More than 29,000 known Scheduled chemicals are contained in the OPCW Scheduled Chemicals Database, yet due to the nature of the families of chemicals covered under these Schedules, there are actually an infinite number of possible Scheduled chemicals that can exist. About 1,400 Scheduled chemicals have been declared to the OPCW and are described in the recently updated 2014 Handbook on Chemicals (Appendix 2 of the Declarations Handbook).

The 2014 brochure on the most traded Scheduled chemicals contains information on 49 widely used Schedule 2 and 3 compounds. Schedule 1 chemicals also have non-chemical weapon uses that include (but are not in any way limited to) HN1, Schedule 1A(6), used in chemotherapy and has been suggested for use in the preparation of pharmaceutical compositions for treating neuroinflammatory skin diseases; and saxitoxin, Schedule 1A(7), which has been suggested for use in anti-wrinkle cosmetics.

Click here for a new mystery image and don't miss the science images of November.

Looking for some chemistry for the coming holidays? See the 2014 Chemistry Advent Calendar.

And finally, in case you ever have reason to anesthetize an octopus.

Crowdsourcing:

Can you determine the optimal number of reports required per week for flu to provide early detection of significant rise in illness rates and accurate tracking of overall rates? And speaking of flu, you may want to watch this and find out how to avoid getting sick on an airplane...

Ensuring that the grass is always greener on a golf course – can you build a monitoring system?

Can you explain what is sleep?

The Bioeconomy

As we discuss the convergence of chemistry and biology, like so much of S&T, it can appear abstract and disconnected from our day to day life and work. However, the science we think of as convergence is very real and economically important; one might say that "The Bioeconomy" is enabled by convergence (see also the Spiez CONVERGENCE Report).

The Science for Diplomats event at CSP-19 provided an introduction to the bioeconomy and its scientific and technological basis. We feature this topic here for those of you who were unable to attend or who may be interested in further information.

The bioeconomy refers to the set of economic activities relating to the development, production and use of biological products and processes. These activities include production of chemicals, materials, and energy. With new biotechnological advances we are seeing considerable investment in bio-based products in a number of CWC States Parties (see also the EU Bioeconomy Portal and a report on jobs, investment and innovation in the US Bioscience industry). The bioeconomy relies on having accessible sources of biomass that can be converted to products and/or energy.

Fermentation is one of the oldest biotechnology processes known (yes, beer has been around for a very long time!) and can be used to produce a broad variety of chemicals; for example, industrial scale fermentation provides two important commodity chemicals, lactic acid and succinic acid.

Fermentation processes can be used in the production of plastics and other polymeric materials. Bio-based methods offer the possibility to eliminate the use of certain toxic chemicals in a process; for example bio-based nylon does not require hydrogen cyanide (a Schedule 3 chemical) to produce the monomeric starting material.

Millions of tonnes of biofuels are produced and consumed each year; biofuels are even used for air travel. Biofuel economics is dependent on world oil supply and prices; never the less, considerable effort has been put forth in evaluating suitability of crops and microorganisms for use in biorefineries (more details on crops can be found here). Waste products from other processes of commercial interest can also be used to produce biofuels. High octane biofuels, suitable for your favourite high compression internal combustion engine, are possible (technical details can be found here).

Scientific and technological advances continue to emerge from researching bio-based processes. These include *in-situ* product recovery from whole cell processes, increased photosynthetic efficiency in plants and algae, and new methods to obtain valuable chemicals from agro/industrial waste.

As we move into the future we will continue to see new biotechnological advances coming from scientific work in fields that

Upcoming S&T Related Events:

11 - 12 December 2014
New Technologies and Approaches for Information Analysis to Support Non-Proliferation and Disarmament Verification;

Vienna Center for Disarmament and Non-Proliferation (VCDNP) and the James Martin Center for Non-proliferation Studies (CNS),Vienna, Austria

28 - 29 January 2015
5th Meeting of the Scientific Advisory Board's Temporary Working Group on Verification. The Hague

4 - 6 February 2015
The Unmanned Systems Expo 2015. The Hague

12 - 16 February 2015
AAAS Annual Meeting 2015: Innovations, Information, and Imaging. San Jose, California, USA.

21 - 26 March 2015
249th American Chemical Society (ACS) National Meeting & Exposition. Denver, Colorado, USA.

During the open session of the ACS Board of Directors meeting, the 2013 Nobel Peace Prize recipient, the OPCW will be honoured for its work in finding peaceful applications of chemical sciences worldwide.

22 - 26 June 2015
CTBT Science and Technology Conference (SnT2015)
Vienna, Austria

include Green Chemistry and the science of the bioeconomy may eventually bring humans to Mars!

Science Technology, Industry and Policy

We regularly see reports that provide insights into observed global, regional, and national S&T trends. These studies are helpful in understanding driving forces behind technological change and can be a source of information on S&T policy decisions across the States Parties. We hope you find this feature useful.

The Nature Index 2014 Global supplement provides a snapshot of results from the new Nature Index, comparing national trends in S&T funding, policy, and output of countries and institutions. An assessment of the structure and efficiency of national research systems (the "scientific competitiveness of nations") using citation data from scientific articles in different S&T domains was also recently published. When reviewing these reports it useful to be aware of the impact of international collaborations and (and how this can be influenced by the number of participating collaborators) on scientific outputs.

The OECD Science, Technology and Industry Outlook for 2014 reports that R&D spending by China will soon overtake that of the European Union and the United States. Highlights and full report are available from the OECD.

Oxford Economics published a report on the competitiveness of the European chemical industry. A response to this report from the European Industry Council (Cefic) can be found here. The EU Industry Alliance Manifesto and the Cefic Sustainability Report may also be of interest. For a look at industry in other regions, see the case study of initiatives and challenges of a chemical industries council in Malaysia.

Reports related to global health and the life sciences include a look at 2014-2015 trends (full report here), the impact of patents in India on access to medical drugs, agronomic and economic impacts of GMO crops (technical details here) and the potential impact of synthetic biology on economic development of marine biotechnologies.

The CRISPR-CAS9 genome editing technology is considered the most significant of all current biotechnology advances. The economic potential of this technology is exemplified by a fight over intellectual property that has moved from the laboratory into the courtroom.

Additional assessments of S&T related issues and how they integrate into more general policies and trends can be found in The 2014-2015 Global Competitiveness Report from the World Economic Forum.

Understanding and addressing the issues presented in this section requires sound technical advice and input; underscoring the need for effective science communication, science advice, and science diplomacy contributions to policy and decision making.

19 - 22 July 2015
12th World Congress on Industrial Biotechnology. Montreal, Canada.

6 - 13 August 2015
IUPAC 2015
48th General Assembly
45th World Chemistry Congress. Busan, Republic of Korea

27 September - 1 October 2015
ECCE10 (10th European Congress of Chemical Engineering)

ECAB3 (3rd European Congress of Applied Biotechnology)

EPIC5 (5th European Process Intensification Conference)

Nice, France.

18 - 21 November 2015

16th Asian Chemical Congress. Dhaka, Bangladesh.

Contact:

Questions, comments, suggestions, contributions? Or to be added to the mailing list, please contact the Science Policy Adviser in the Office of Strategy and Policy

Environmental Fate

Environmental fate is a term used to describe the processes by which chemicals migrate within and are transformed by the environment. This includes environmental persistence; reactivity and degradation; migration; and bioaccumulation in living organisms.

Of relevance to the CWC are reports on the environmental fate of chemicals related to chemical warfare agents and their persistence on building materials. Other studies have shown how the properties of soil can influence uptake of agents into the environment.

At least 127 dump sites are known for sea dumped chemical weapons. Studies have been conducted to examine the possible migration of chemicals contained in these munitions into the sea and to look for bioaccumulation. Underwater construction projects close to areas with sea dumped weapons have also raised concerns.

Assessing environmental fate involves many interactive and complex processes; this is exemplified by the fate of pesticides. Neonicotinoids provide a pertinent example, these pesticides have been blamed for declining bee populations, yet data collected and compared across multiple studies can generate uncertainty. In the case of pharmaceuticals, trace amounts are commonly found in water systems near urban areas; both negative and positive effects on fish populations are possible depending on the pharmaceutical in question (the technical report on "happy" fish can be found here).

Nanoparticles increase the complexity of environmental fate. Particulate matter in air pollution, for example, can facilitate chemical migration (biological migration too; technical details here). Airborne particulates with nanometer and micrometer dimensions come from sources that include engine exhaust. Nanoparticles also have applications for environmental decontamination.

With the large numbers of chemicals we are routinely exposed to, continuous efforts are made to determine potential health risks - often for chemicals where there is little or no available exposure data (more details can be found here).

Chemicals in the environment can be studied by a variety of methods, including chemical measurements from satellites. Of course, terrestrial and oceanic based monitoring is necessary to ensure a complete picture. Data management issues, however, can create challenges for large scale real-time monitoring networks.

Even with large amounts of data, assessing chemical impact on the environment is complicated. One method is the comparison of an ecological footprint (natural resources required to sustain an individual or a country) to resources that are actually available in the environment. Calculations of such indicators for European aquatic ecosystems were recently reported by scientists from Denmark and The Netherlands.

	The same mechanisms that lead to degradation and bioaccumulation of toxic chemicals in the environment also provide opportunities for environmental remediation. Examples include plants and microorganisms that can uptake heavy metals and arsenic, plants that can uptake petroleum based hydrocarbons and plants that can be used to detect the use of and potentially even degrade nerve agents (details can be found here). The use of harvestable plants may also enable recovery and reuse of chemicals – this is of particular interest for precious metals (the most suitable plants are those that contain appropriate metal binding proteins). To identify suitable microorganisms for chemical cleanup, we can look to the animal world and the types of gut bacteria found in sheep that eat and digest explosives, worms that eat polyethylene (details here) or vultures that regularly ingest toxins and pathogens harmful to humans (details here). In some cases, just leaving garbage out for the local insect population can set an efficient environmental cleanup process into motion (details here). Then there is the use of cigarette ash to remove arsenic from water (details here). When considering this method, note that the process for generating cigarette ash may also result in its own environmental fate life cycle.