Science for Diplomats at RC-4 and the Spiez Laboratory Present:

Convergence and Solving Chemical Mysteries

a Transdisciplinary Look at Scientific Advances and Problem Solving

Friday, 23 November 2018
13:00 - 15:00 Europe Room World Forum
Light Lunch provided
Solving the mystery

Solving a Chemical Mystery

Your task is to determine the provenance of the “sample” before you. Just follow these instructions!

In front of you sit results from a sample analysis provided by our chemical and biological analysis laboratory, along with a puzzle that indicates where your sample may have been collected. Your task is as follows: Solve the puzzle (we recommend collaboration) and then consider the chemical analysis.

1. Do the chemical analysis results suggest the presence of a chemical weapon agent? If so, which one?
   • This can be determined by recognizing degradation products and/or data that can be found on the “Degradation and Analysis of Scheduled Chemicals” handout.
   • To assist your interpretation of the data, refer to the back of this card.
   • When you are ready, raise your molecule and one of our capable assistants will check your answer and provide you with additional information.

2. In addition to the analytical results, other evidence has been collected that requires consideration and perhaps more puzzle building. Use this additional information to match your sample to the site (A-K) from which it was collected.

3. One last question: is your sample actually from a Chemical Weapon agent?

Good Luck!

Go to:

- Sample 1
- Sample 2
- Sample 3
- Sample 4
- Sample 5
- Sample 6
- Sample 7

This exercise has been brought to you by Sofia Sola Sancho, Maria Hennke, Nadine Gürer and Jonathan Forman, as part of Science for Diplomats at RCI and the Spiez Laboratory. Present: Convergence and Solving Chemical Mysteries, a Transdisciplinary Look at Scientific Advances and Problem Solving.
Solving the mystery

Visualising and Reading Molecules

Go to:

- Sample 1
- Sample 2
- Sample 3
- Sample 4
- Sample 5
- Sample 6
- Sample 7
Match your sample to the source!

Go to:
- **Sample 1**
- **Sample 2**
- **Sample 3**
- **Sample 4**
- **Sample 5**
- **Sample 6**
- **Sample 7**
Follow the instructions:
1. Identify Sample 1 on the Degradation and Analysis of Scheduled Chemicals poster. A guide on how to read molecular structures is available here.
2. Is it a degradation product of a chemical weapon? If yes, which one?
3. Open the source location puzzle.
4. Using other clues in the photo, can you determine where your sample was collected?
5. Did it actually come from a Chemical Weapon Agent?
**Solution:**

**Sample 1:** Possible degradation products of HN-3

**Site H:** (shaving cream production facility)

Nitrogen mustard (HN-3)

Sample 1 is not a Chemical Weapon agent

Triethanolamine is used in the manufacture of shaving cream.
Follow the instructions:
1. Identify Sample 2 on the Degradation and Analysis of Scheduled Chemicals poster. A guide on how to read molecular structures is available [here](#).
2. Is it a degradation product of a chemical weapon? If yes, which one?
3. Open the source location puzzle.
4. Using other clues in the photo, can you determine where your sample was collected?
5. Did it actually come from a Chemical Weapon Agent?
Solution:

**Sample 2:** Possible degradation products of BZ

*Site C* (Pharmaceutical Production Facility)

BZ precursors are used in the manufacturing of pharmaceuticals.

**Sample 2 is not a Chemical Weapon Agent**
Follow the instructions:
1. Identify Sample 3 on the Degradation and Analysis of Scheduled Chemicals poster. A guide on how to read molecular structures is available here.
2. Is it a degradation product of a chemical weapon? If yes, which one?
3. Open the source location puzzle.
4. Using other clues in the photo, can you determine where your sample was collected?
5. Did it actually come from a Chemical Weapon Agent?
Solution:

Sample 3: Possible degradation products of Sulfur mustard

Site G (barn at the orchard)

The fruit ripening gas Ethylene can be used to produce Sulfur Mustard by the Levenstein process.

Sample 3 is from a Chemical Weapon Agent
Follow the instructions:
1. Identify Sample 4 on the Degradation and Analysis of Scheduled Chemicals poster. A guide on how to read molecular structures is available [here](#).
2. Is it a degradation product of a chemical weapon? If yes, which one?
3. Open the source location puzzle.
4. Using other clues in the photo, can you determine where your sample was collected?
5. Did it actually come from a Chemical Weapon Agent?
Sample 4: Possible degradation products of Sarin

Site J (biomedical research facility)

Sarin is used at this site for research on medical countermeasures.

Sample 4 is a Chemical Weapon Agent used for non-prohibited purposes.
Follow the instructions:
1. Identify Sample 5 on the Degradation and Analysis of Scheduled Chemicals poster. A guide on how to read molecular structures is available here.
2. Is it a degradation product of a chemical weapon? If yes, which one?
3. Open the source location puzzle.
4. Using other clues in the photo, can you determine where your sample was collected?
5. Did it actually come from a chemical weapon agent?
Solution:

Sample 5: Possible degradation products of Lewisite 1

An old munition containing Lewisite 1 was found in the K dig site.

Sample 5 is from a Chemical Weapon Agent
Follow the instructions:
1. Identify Sample 6 on the Degradation and Analysis of Scheduled Chemicals poster. A guide on how to read molecular structures is available here.
2. Is it a degradation product of a chemical weapon? If yes, which one?
3. Open the source location puzzle.
4. Using other clues in the photo, can you determine where your sample was collected?
5. Did it actually come from a Chemical Weapon Agent?
**Solution:**

**Sample 6:** Characteristic molecular ion seen in a Mass Spectrum of Saxitoxin

**Site B** (red algae contamination in oyster farm)

Saxitoxin (STX) is a potent neurotoxin and the best-known paralytic shellfish toxin (PST). Saxitoxin is naturally produced by red algae.

While Sample 6 could be considered a Chemical Weapon. However, the red algae are not producing it with intent to proliferate chemical weapons use by humans.
Follow the instructions:
1. Identify Sample 7 on the Degradation and Analysis of Scheduled Chemicals poster by solving the cube puzzles.
2. Is it a degradation product of a chemical weapon? If yes, which one?
3. Open the source location puzzle.
4. Using other clues in the photo, can you determine where your sample was collected?
5. Did it actually come from a Chemical Weapon Agent?
Sample 7: Peptide Sequencing Analysis of Ricin

**Site E** (castor plant nursery)

**Sequence 1** = LEQLAGNLR

**Sequence 2** = YTFASFGGNYDR

**Characteristic peptide sequences of Ricin D Chain A**

Ricin is a lectin produced in the seeds of the castor oil plant, Ricinus communis.

While Sample 7 could be considered as coming from a Chemical Weapon Agent, the nursery growing castor plants for non-prohibited purposes (plants to decorate gardens)
Organophosphorus (OP) Nerve Agents and their Countermeasures

### Examples of nerve agents:

- **VX**
- **Russian VX**
- **Soman (GD)**
- **Tabun (GA)**
- **Sarin (GB)**
- **Cyclosarin (GF)**

### Mechanisms

- **Atropine**: blocks the action of ACh at muscarinic receptors and treats SLUDGE syndrome (salivation, lacrimation, urination, defecation, gastrointestinal motility, emesis)
- **Oximes**: reactivate acetylcholinesterase before the process of aging (e.g., irreversible inhibition of the enzyme). Oximes can be co-administered with atropine. Commonly used oximes include pralidoxime chloride, HI-6, trimedoxime and obidoxime.

### Secondary effect

- **Benzodiazepines** (BDZs, a class of anticonvulsants) bind to the gamma sub-unit of the GABA receptor. Binding results in an allosteric (structural) modification of the receptor that increases receptor activity and inhibits excessive nerve cell activity. BDZs used for this purpose include diazepam, lorazepam and midazolam.

### Other reported countermeasures

- **Bioscavengers**: enzymes that detoxify OPs by stoichiometric reaction or by catalytically clearing the OPs into biologically inert products. Butyrylcholinesterase (illustrated below) represents an example of a biospecific bioscavenger.

- **Nafamostat mesilate**, **Tefenon**, **Metopimazine**, **Pramine** have been reported to neutralize nerve agents. This is not a generally recommended procedure but there are reports of its use.

### References