

**The Resurgent Chemical Weapons Threat:
Current Challenges to the Chemical Weapons Convention**

Novichoks and the CWC Schedules

Stefano Costanzi, PhD, MIS



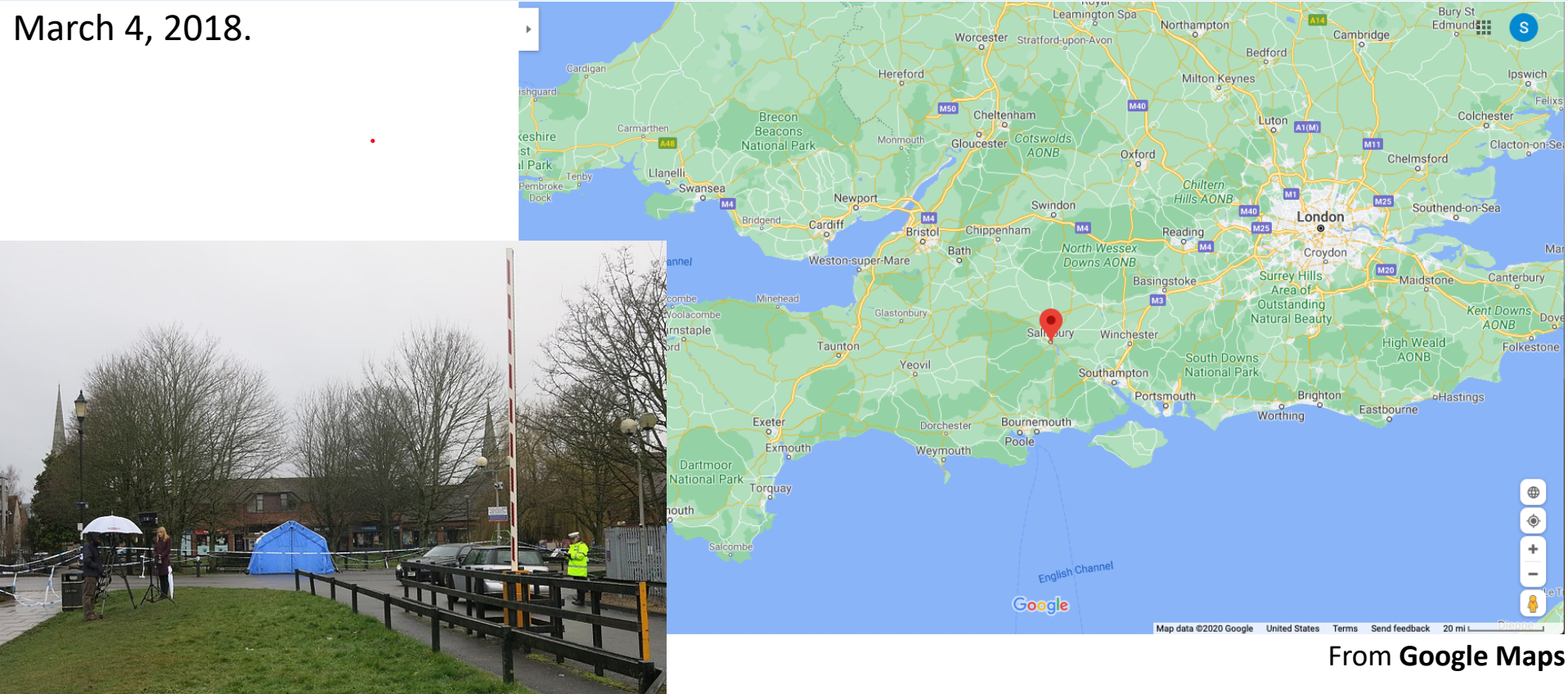
AMERICAN UNIVERSITY
W A S H I N G T O N , D C

Nov 17, 2020

Webinar Organized by George Mason University, Schar School of Policy and Government

The Salisbury Incident: Novichoks in the Spotlight

March 4, 2018.



From **Google Maps**

Photo from **Wikimedia Commons**

https://commons.wikimedia.org/wiki/File:Police_forensics_tent_at_The_Maltings,_Salisbury.jpg

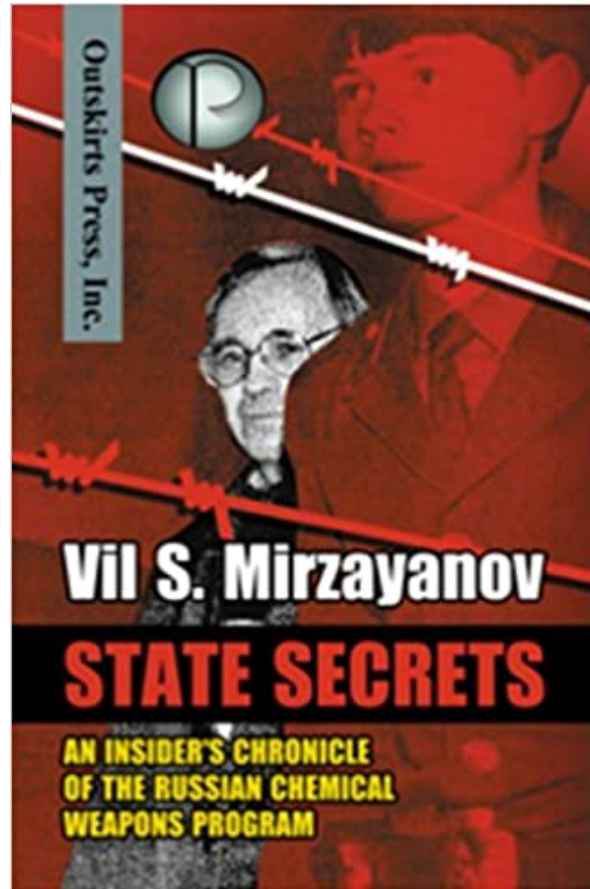
Novichoks: Poisons from the Cold War

- Nerve agents developed in the Soviet Union starting in the 1970s
- Inhibit a key enzyme for the functioning of the nervous system



Bester et al. 2020. <http://www.rcsb.org/structure/6NTL>

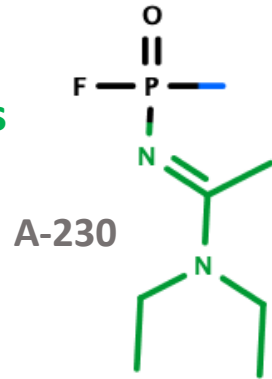
Novichok and Vil Mirzayanov



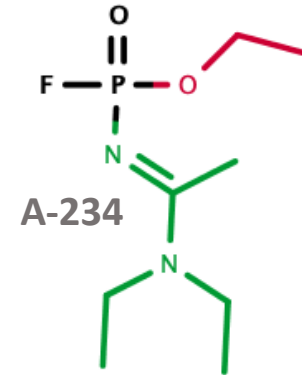
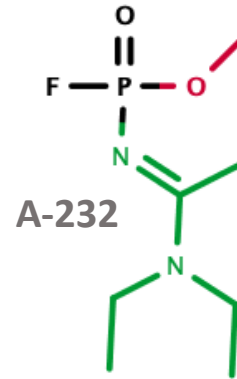
Mirzayanov's structures

Phosphonates

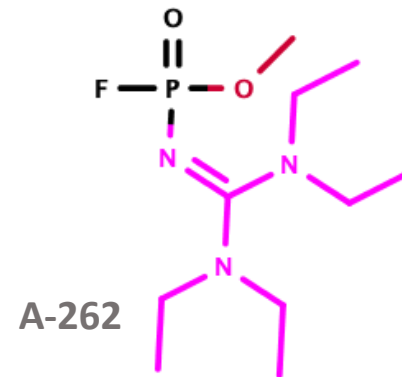
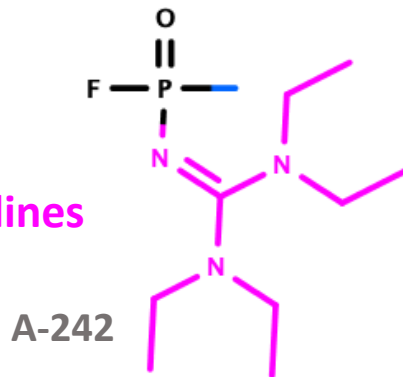
Amidines



Phosphates



Guanidines



Novichoks and the CWC Schedules

- A tiered system of three schedules

- Schedule 1, Schedule 2, Schedule 3

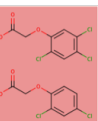
- Part A

- Chemical Warfare agents

- Part B

- Precursors for their synthesis

No Novichoks!

Nerve agents	CWC 1A1	O-Alkyl (<=C10, incl. cycloalkyl) alkyl (Me, Et, n-Pr or i-Pr)-phosphonofluoridates	CR0001	---		---	WA ML7 b.1.a	---	*
Nerve agents	CWC 1A1 Example 1	Sarin: O-isopropyl methylphosphonofluoridate	107-44-8	7871		CC(C)OP(C)(F)=O	InChI=1S/C4H10FO 2HCl+42Z 8(3,5)6/NH,1-3H3	WA ML7 b.1.a Example 1	Download 2D Structure (SDF) Download 2D Structure (MOL) Show 3D Structure NIST Chemistry WebBook
Lewisites	CWC 1A5-1	Lewisite 1: 2-Chlorovinylchloroarsine	541-25-3	537298		ClC=C[As](Cl)Cl	InChI=1S/C2H2AsCl3 3/c4-2-1-3/5/b1-2H62-1+	WA ML7 b.2.b.1	Download 2D Structure (SDF) Download 2D Structure (MOL) Show 3D Structure NIST Chemistry WebBook
Toxins	CWC 1A8	Ricin	8009-86-3	202679		---	---	---	Show 3D Structure
Exceptions	CWC 2B4 Exception 1	O-Ethyl S-phenyl ethylphosphonothiothionate	844-22-9	13678		CCOP(=S)(CC)SCC	InChI=1S/C10H15SO P2S2+3-11- 12/13-4-214-10-8- 6-5-7-9-10/5-9H3- 4H2,1-2H3	---	Download 2D Structure (SDF) Download 2D Structure (MOL) Show 3D Structure NIST Chemistry WebBook
Defoliants	Wassenaar ML7 b.4.b Free Acid Form	2,4,5-trichlorophenoxyacetic acid mixed with dichlorophenoxyacetic acid (Agent Orange) Note: this is the entry name given in ML7	8015-35-8 Note: this CAS Registry Number is not given in ML7 but can be inferred from the name given in ML7	24683		OC(=O)COCc1cc(Cl)c(Cl)c(Cl)c1Cl	InChI=1S/C8H5Cl3O3 Cl3C8H5Cl3O3/cb- 4-1-6(11)/12- 5(4)/10(14)- 8(12)/13-3-5-1-2- 7(6)(10)-5(13)- 8(11)/12H,1-2H,3H2, (H,12,13),1-3H,4H2, (H,11,12)	---	Download 2D Structure (SDF) Download 2D Structure (MOL) Show 3D Structure NIST Chemistry WebBook

*Snippet of annotated CWC Schedules, from costanziresearch.com

Two Parallel Proposals

- Joint proposal (U.S.A., Canada, Netherlands)

1. A family of **phosphonates** with **amidine** branches
2. A family of **phosphates** with **amidine** branches



- Russian Federation

1. A-230
2. A-232 and A-234
3. A-242
4. Two families of carbamates
5. Ellison and Hoenig's alternative Novichok structures



Costanzi and Koblenz. Nonproliferation Review, 2019.

<https://www.tandfonline.com/doi/full/10.1080/10736700.2019.1662618>



Two Parallel Proposals

- Joint proposal (U.S.A., Canada, Netherlands)

1. A family of **phosphonates** with **amidine** branches
2. A family of **phosphates** with **amidine** branches

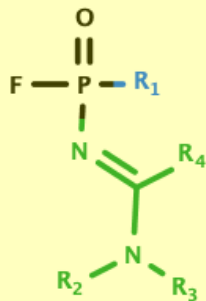
- Russian Federation

1. A-230
2. A-232 and A-234
3. A-242
4. Two families of carbamates
5. ~~Ellison and Hoenig's alternative Novichok structures~~

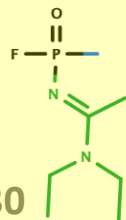


CWC Conference of State Parties 2019

CWC 1A13



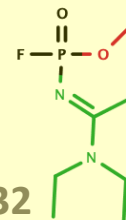
A-230



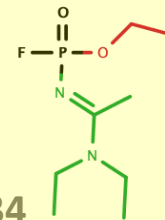
CWC 1A14



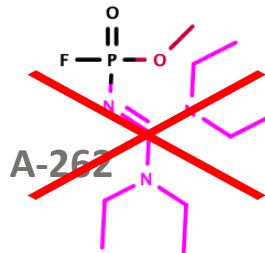
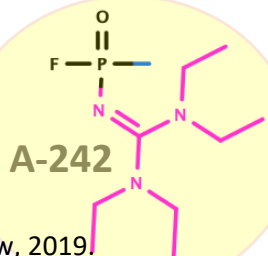
A-232



A-234



CWC 1A15

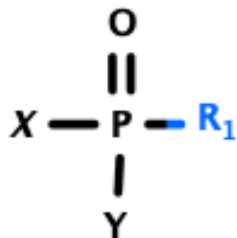


+ CWC 1A16: carbamates

Australia Group

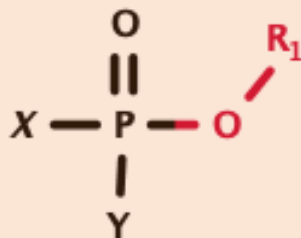
- No precursors added to part B of the CWC Schedules
- However, 22 precursors were added to the Australia Group

Phosphonate precursors

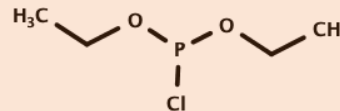


AG 4, 5, 22, 23

Phosphate precursors

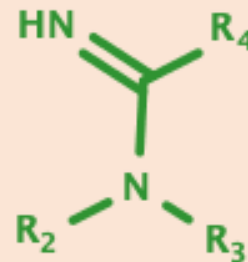


AG 67– AG 72



AG 70

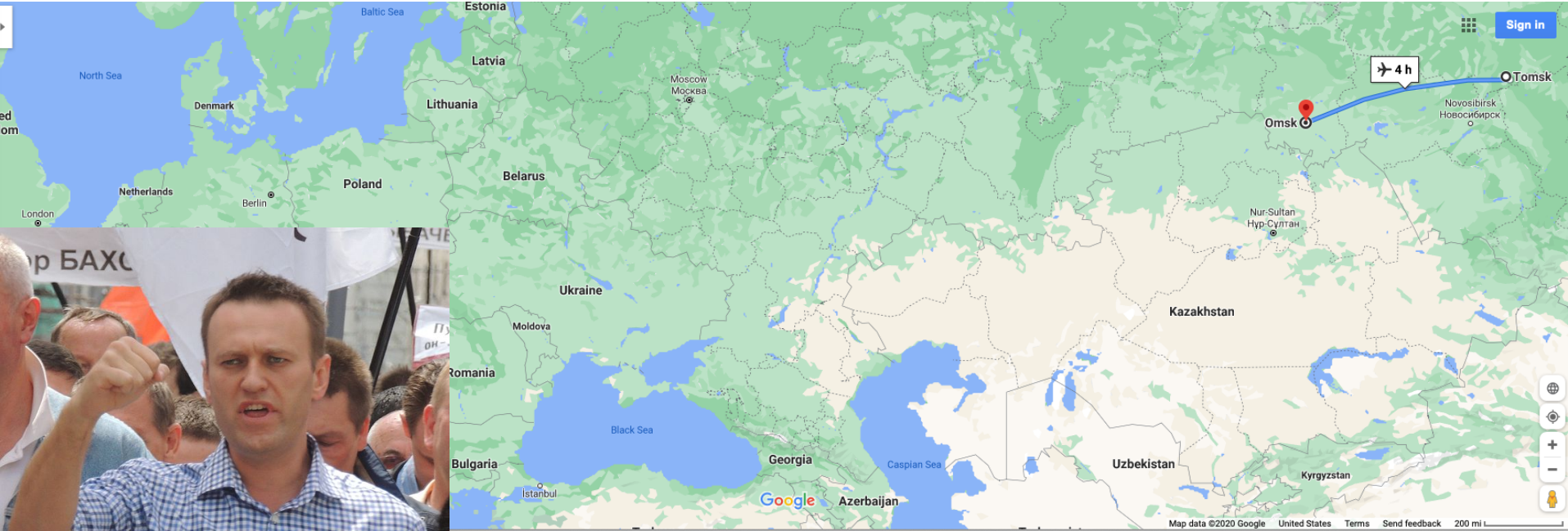
Amidine precursors



AG 73 – AG 87

The Navalny Incident

August 20, 2020.



From **Google Maps**

Photo from Wikimedia Commons

https://commons.wikimedia.org/wiki/File:Alexey_Navalny_at_Moscow_rally_2013-06-12_3.JPG



The Navalny Incident: A-262?

- Analyses from five independent laboratories
 - A novichok agent, not covered by the CWC amendment; Similar characteristics to CWC 1A14 and CWC 1A15
 - OPCW S/1906/2020 <https://www.opcw.org/sites/default/files/documents/2020/10/s-1906-2020%28e%29.pdf>

Phosphonates

Phosphates

Amidines

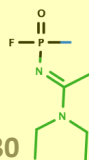
A262 or closely related analog?

Guanidines

CWC 1A13



A-230



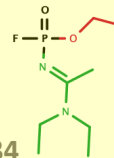
CWC 1A14



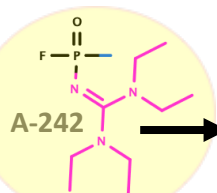
A-232



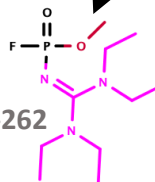
A-234



CWC 1A15



A-262



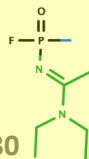
Further Amendments to the CWC Schedules?

- What's Missing?

CWC 1A13



A-230



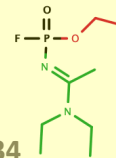
CWC 1A14



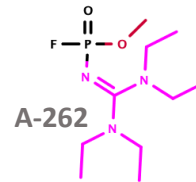
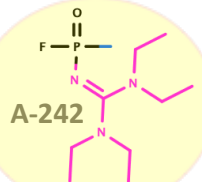
A-232



A-234



CWC 1A15



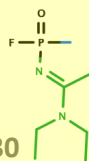
Further Amendments to the CWC Schedules?

- What's Missing?
 - A262: absent

CWC 1A13



A-230



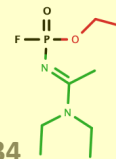
CWC 1A14



A-232

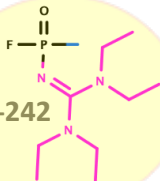


A-234

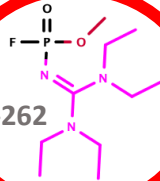


CWC 1A15

A-242



A-262

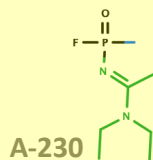


Further Amendments to the CWC Schedules?

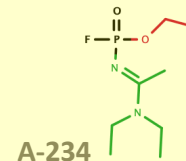
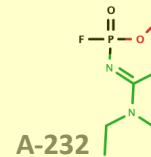
- What's Missing?

- A262: absent
- CWC 1A15: just one chemical (A-242)

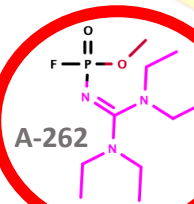
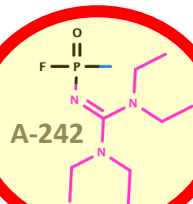
CWC 1A13



CWC 1A14



CWC 1A15



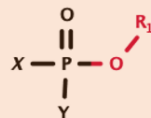
Further Amendments to the CWC Schedules?

- What's Missing?

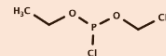
- A262: absent
- CWC 1A15: just one chemical (A-242)
- No precursors

Australia Group

Phosphate precursors

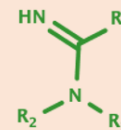


AG 67–AG 72



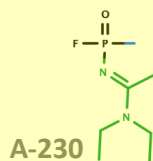
AG 70

Amidine precursors



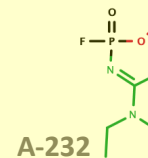
AG 73 – AG 87

CWC 1A13

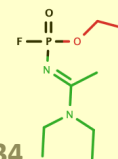


A-230

CWC 1A14



A-232



A-234

CWC 1A15



A-242



A-262

Thank you!



Costanzi Research

[Home](#)

Comp Chem ▾

CW Nonproliferation ▾

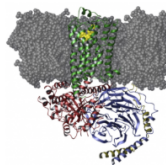
Twitter

About Us

Chemistry, Computers, and CW Nonproliferation

Led by [Dr. Stefano Costanzi](#) and based at the [Department of Chemistry of American University](#), the Costanzi Research Group focuses on two main research lines:

- The application of computational chemistry to the study of the interactions of chemicals with living organisms



- Policy analysis and conceptualization of solutions to stem the proliferation of chemical weapons (CW)



<https://costanziresearch.com>

costanzi@American.edu

News and Highlights

Curated Tweets by @s_costanzi



