THE FOUR LIKELY BINARY AGENTS

Working paper
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Last Updated, January 2013

- **Binary sarin (GB2) – developed by the U.S.**
- **Binary soman (GD2)**
- **VX binary (VX2) – developed by the U.S**
- **Novichok agent ("New Comer) –developed by the Soviets**

Additionally, Eric Croddy has written that VNSAs may use "binarytype designs" in an attack…with simple designs most likely using common chemical ingredients (e.g., cyanide.)"[1] Aum is an example of this.

1. **Binary sarin**. With binary sarin (also referred to as "GB binary" and "GB2") a forward container has methylphosphonic difluoride (DF), while a second, rear container has an isopropyl alcohol and isopropylamine solution (OPA). The DF resides in the munition prior to use. The OPA is added just prior to launch. After deployment of the weapon, the two canisters rupture, "the isopropyl amine binds to the hydrogen fluoride generated during the chemical reaction, and the chemical mixture produces GB."[2] Experts note that, "The final product of the weapon is of the same chemical structure as the original nerve agent. The term binary refers only to the storage and deployment method used, not to the chemical structure of the substance."[3] With regard to how long it takes the DF and OPA to mix before binary sarin is extant, Eric Croddy notes that, "as in any chemical reaction, a certain amount of time is required for the [binary] reaction to run its course. In the case of GB binary, this required about seven seconds."[4]

2. **Binary soman** (also referred to as "GD binary" and "GD2"). "With binary soman (GD binary, GD2): DF [methylphosphonic difluoride] is located in [one] canister, while a mixture of pinacolyl alcohol and an amine is in a second canister. After deployment of the weapon, the two canisters rupture and the chemical mixture produces binary soman.[5]

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[1] Eric Crody, "Binary Chemical Munitions," in Eric A. Croddy and James J. Wirtz, eds., *Weapons of Mass Destruction Encyclopedia, Volume One: Chemical and Biological Agents* (ABC Clio: Santa Barbara, CA, 2005), p. 41.
[2] Larissa I Velez-Daubon, MD; Chief Editor: Robert G Darling, MD, "CBRNE - Nerve Agents, Binary - GB2, VX2," Medscape, updated: June 7, 2012. Available at: http://emedicine.medscape.com/article/831901-overview
[3] Velez-Daubon and Darling, "CBRNE - Nerve Agents, Binary - GB2, VX2."
[4] Eric Crody, "Dilrour (DF, Delfuoromethyl-phosphonate," in Eric A. Croddy and James J. Wirtz, eds., *Weapons of Mass Destruction Encyclopedia, Volume One: Chemical and Biological Agents* (ABC Clio: Santa Barbara, CA, 2005), p. 117-118.
[5] Velez-Daubon and Darling, "CBRNE - Nerve Agents, Binary - GB2, VX2."

3. **VX binary (VX2)**: "O-Ethyl O-2-diisopropylaminoethyl methylphosphonite (QL) is in 1 canister. The other canister contains elemental sulfur. When the weapon is fired, the canisters rupture and the chemical mixture produces VX."
4. "Novichok agent ("Newcomer") : a series of nerve agents developed by the Soviet Union in the 1980s and 1990s, all in the "third generation nerve agent" category. Some of these agents (Novichok-5, Novichok-7) are binary agents."[6]

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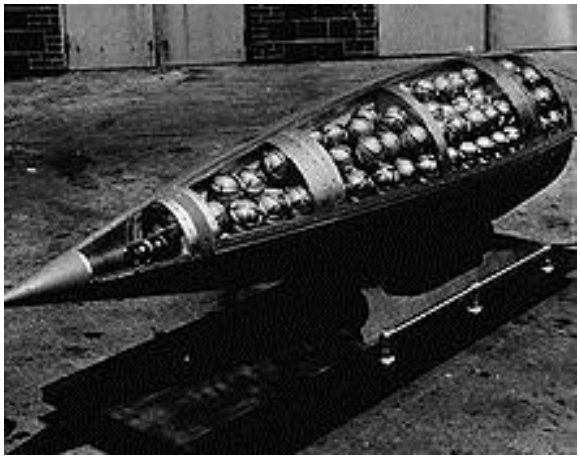

"Binary munitions were once intended by the United States as a means of retaining a retaliatory capability without the necessity of an agent stockpile. The relatively nontoxic intermediates could be stored separately and not placed in proximity to one another until just before use. This requires some human engineering to ensure the munitions designs permit simple, rapid mating of the ingredient containers and production of the lethal agent en route to the target. The binary system was envisioned almost exclusively for application to the standard nerve agents. Although at least three types of binary munitions were planned, only one (155-mm artillery shell) was in production when the United States ended CW production. The Russians claim to have considered binary munitions but not produced any. The Iraqis had a small number of bastardized binary munitions in which some unfortunate individual was to pour one ingredient into the other from a Jerry can prior to use." Crody et al.

BINARY CHEMICAL MUNITIONS THAT DELIVER SARIN

Chemical agents can either be stored in bulk quantities or loaded into munitions. With the nerve agents in particular, the quality of the initial material must be excellent and they must be stored under inert conditions with the absolute exclusion of oxygen and moisture. Generally, an overlay of dry helium was employed to leak check munitions. A small amount of stabilizer (2-4 percent) was also used to extend agent life span. The United States stored agent in both bulk containers and in munitions. In the latter instance, the munitions were normally stored in revetted bunkers.

"The binary system was envisioned almost exclusively for application to the standard nerve agents."[7]

[6] Ibid.

"Binary CW weaponry was reportedly the "goal of every major chemical weapon producing nation since the 1960s through the early 1990s. The weapons were composed of two benign chemicals, but when launched would combine to form the desired agent. This was advantageous because it allowed for safe storage and transport of the weapons."

- **Pros** of Binary Munitions:
  - State can retain a retaliatory capability without the requirement of an agent stockpile.[8]

- **Cons** of Binary Munitions:
  - **"**The relatively nontoxic intermediates could be stored separately and not placed in proximity to one another until just before use. This requires some human engineering to ensure the munitions designs permit simple, rapid mating of the ingredient containers And Production Of The Lethal Agent En Route To The Target."

EXAMPLES OF STATES USING A BINARY DELIVERY SYSTEM TO DELIVER GB

Russia: "publicly accused by dissidents within their own agencies of developing new binary agents, and the Iraqis are known to have constructed binary bombs and missile warheads, albeit with crude manual mixing of the reactants.[9]"

Iraq: "The Iraqis had a small number of bastardized binary munitions in which some unfortunate individual was to pour one ingredient into the other from a Jerry can prior to use."[10]

United States: "The U.S. type classified and produced a GB (sarin) binary nerve agent weapon, the M687 projectile (a 155-mm artillery shell), and was in the late stages of

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[7] From *The Militarily Critical Technologies List Part II: Weapons of Mass Destruction Technologies* (ADA 330102), "Chemical Weapons Technology" - U.S. Department of Defense, Office of the Under Secretary of Defense for Acquisition and Technology, February 1998, p. Available at: http://www.fas.org/irp/threat/mctl98-2/p2sec04.pdf

[8] Federation of American Scientists, "Chemical Weapons Production and Storage," no date. Likely ~ 2000. Available at: http://www.fas.org/programs/bio/chemweapons/production.html

[8] http://www.nti.org/gsn/article/south-korea-completes-chemical-weapons-disposal/

[9] http://www.fas.org/irp/threat/mctl98-2/p2sec04.pdf 11-4-3

[10] Federation of American Scientists, "Chemical Weapons Production and Storage," no date. Likely ~ 2000. Available at: http://www.fas.org/programs/bio/chemweapons/production.html

development of two other binary weapons when its offensive CW program was terminated. The Russians have been publicly accused by dissidents within their own agencies of developing new binary agents, and the Iraqis are known to have constructed binary bombs and missile warheads, albeit with crude manual mixing of the reactants.[11]

The U.S. type classified and produced a GB (sarin) binary nerve agent weapon, the M687 projectile (a 155-mm artillery shell), and was in the late stages of development of two other binary weapons when the United States' offensive CW program was terminated.[12]

South Korea: Before it destroyed its CW while ascending to the CWC, South Korea possessed a CW arsenal believed by some to have included 400 to 1,000 metric tons of **sarin nerve agent** contained in artillery shells, while the rest could have been **binary agents** that would have become dangerous when mixed together.[13]

Syria ?

"… former Israeli Gen. Shlomo Brom said he thinks there is only a small danger of unconventional weapons being acquired by Hezbollah or al-Qaida-backed extremists. He pointed out that Syrian chemical warfare materials, which are understood to be kept in binary form, are generally stored in different areas from the munitions that would deliver them."[14]

According to Anthony Cordesman, "… Syria has probably the largest and most advanced chemical warfare program in the Arab world, reportedly including thousands of tube and rocket artillery rounds filled with mustard-type blister agents, thousands of bombs filled

[11] http://www.fas.org/irp/threat/mctl98-2/p2sec04.pdf 11-4-3

[12] The Reagan administration reexamined the CW issue in the 1980s and began production of binary sarin artillery shells in 1987. http://www.nti.org/country-profiles/united-states/. Crody argues that the M-687 reached production. Crody Encyclopedia, p. 40.

[13] http://www.nti.org/gsn/article/south-korea-completes-chemical-weapons-disposal/

[14] http://www.nti.org/gsn/article/russia-seen-pushing-assad-regime-against-chemical-arms-use/

with the nerve agents sarin and possibly VX , and binary-type and cluster CW warheads filled with nerve agents for all its major missile systems."[15]

[15] Michael Eisenstat, The Washington Institute, July 12, 2012. Available at: http://www.washingtoninstitute.org/policy-analysis/view/dealing-with-syrias-chemical-weapons-military-options