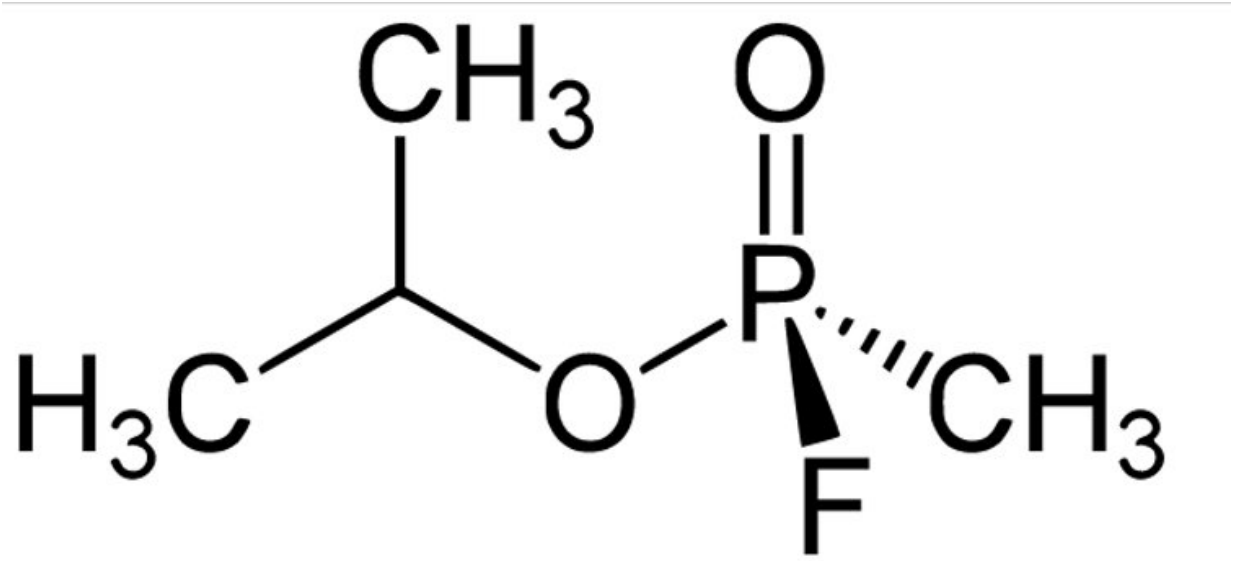
Nerve agents—what are they and how do they work?

March 9 2018, by Simon Cotton



Structure of sarin. Credit: Yikrazuul/wikipedia

The former Russian spy Sergei Skripal and his daughter are in a critical condition in a hospital in Salisbury, UK, following exposure to an unknown nerve agent. Several locations in the city have been cordoned off and decontaminated since the pair were found unconscious on a park bench on March 5. But what are nerve agents exactly and how do they affect the body?

The first nerve agents were invented by accident in the 1930s when researchers were trying to make cheaper and better alternatives to nicotine as insecticides. In their search, German scientists made two organic compounds containing phosphorus that were very effective at killing insect pests. However, they soon discovered that, even in minuscule amounts, the substances caused distressing symptoms in humans exposed to them.

The two substances – too toxic to be used as commercial insecticides in agriculture – became known as tabun and sarin. The research was handed over to the Wehrmacht (the Nazi armed forces), which evaluated them as weapons and began constructing plants to manufacture them. The sarin plant was not operational by the time the Third Reich collapsed, but fell in to the hands of Soviet forces that overran Poland and Germany.

Pesticide research continued after the war and the molecule known as VX was first made in an Imperial Chemical Industries (ICI) laboratory in the UK in 1952. It again proved too toxic to be used in agriculture and it was passed to the UK's Porton Down Chemical Weapons Research Centre, and subsequently to the US government, when the UK renounced chemical weapons. Its destructive power became clear on March 13, 1968. Somehow, the substance escaped from the army's chemical weapons proving ground and killed over 3,000 sheep grazing 27 miles away in the Skull Valley area of Utah.

Since then, other nerve agents have been developed, but much less is known about them, although they are thought to work in broadly the same way. Unlike street drugs, nerve agents cannot be made in your kitchen or garden shed, on account of their toxicity, even in tiny amounts. Synthesis of nerve agents requires a specialist laboratory, with fume cupboards.

Known cases

Nerve agents were not thought to have been deployed until the 1980s. Saddam Hussein's Iraqi forces are understood to have used sarin during the Iran-Iraq war, notably against Kurdish citizens in Halabja in March 1988, leaving an estimated 5,000 dead.

On March 20, 1995, members of the Japanese Aum Shinrikyo cult used umbrellas with sharpened tips to puncture plastic bags and boxes containing sarin while they were travelling on the Tokyo subway system. Fortunately, the sarin used was impure, otherwise the casualty list would have been much longer. As it was, 13 people died and several thousands got sick.

Although there were claims that VX was used during the Iran-Iraq war, until recently, the only known human fatality caused by VX occurred when two members of the Aum Shinrikyo cult used VX to assassinate a former member of their sect in Osaka in 1994.

Two young women, an Indonesian and a Malaysian, are currently on trial in Malaysia, charged with killing Kim Jong-nam, the half brother of Kim Jong-un, North Korea's leader, allegedly by smearing VX nerve agent across his face in an airport in Kuala Lumpur.

Effects on the body

Nerve agents can be absorbed through inhalation or skin contact. In fact, when the Nazis were building their first nerve agent plant, workers wearing protective suits died in agony when nerve agent got through gaps in their suits.

Unlike traditional poisons, nerve agents don't need to be added to food

and drink to be effective. They are quite volatile, colourless liquids (except VX, said to resemble engine oil). The concentration in the vapour at room temperature is lethal. The symptoms of poisoning come on quickly, and include chest tightening, difficulty in breathing, and very likely asphyxiation. Associated symptoms include vomiting and massive incontinence. Victims of the Tokyo subway attack were reported to be bringing up blood. Kim Jong-nam died in less than 20 minutes. Eventually, you die either through asphyxiation or cardiac arrest.

The chemicals work by disrupting the central nervous system. The body uses a molecule called acetylcholine to send messages between cells – when an acetylcholine molecule "arrives", it causes an electrical impulse to be sent. The body constantly has to remove those acetylcholine molecules from the receptors, otherwise there would be a dangerous build-up. It uses an enzyme called acetylcholinesterase (AChE) to do that. However, a nerve agent stops acetylcholinesterase from doing its job.

Antidotes do exist, one being atropine, but have to be administered quickly, otherwise the effect of the nerve agent cannot be reversed. Some antidotes can be administered as prophylactics to troops about to go into battle, if there is a risk of nerve agents being employed. This is obviously a real problem in a civilian situation, where there is no expectation of encountering these chemicals.

We do not yet know which kind of nerve agent poisoned Skripal. While they all work in similar way, different approaches may be needed for decontamination. To decontaminate streets and other hard surfaces, you can use water to flush it out – making sure to use enough to properly dilute the chemical. This works well for the more volatile sarin, which tends to evaporate easily or slowly get broken down by moisture. However, other substances, such as VX, are less volatile and reactive. In this case, bleach and alkali can be used to break the molecules down. In a

situation where we don't know which has been used, a mix of water and bleach may be the best approach.

As more details emerge from the case, we'll know more about the precise substance used and how it should be tackled. Either way, nerve agents are horrendously lethal and chemical warfare is an obscene use of chemicals.

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