The UN has confirmed that the chemical used in Damascus last month was sarin – a lethal poison with no taste, no smell and no colour. Which makes it one of the most murderous weapons in modern warfare.

The Guardian, Tuesday 17 September 2013

An amateur photograph showing a UN weapons inspector collecting samples at Ain Terma, near Damascus. Photograph: Local Commitee of Arbeen/EPA

Now we know. On the morning of 21 August, as the air above Damascus cooled, rockets filled with the nerve agent sarin fell on rebel-held suburbs of the Syrian capital and left scores of men, women and children dead or injured. UN inspectors had been in the country for three days, on a mission to investigate allegations of earlier atrocities. They quickly changed tack. They brokered a temporary ceasefire with the regime and the rebels and made straight for Ghouta. Video reports from the area showed hospital staff overwhelmed and desperate.

Never before had UN inspectors worked under such pressure and in the midst of a war zone. The small team, headed by the Swedish chemical weapons expert Åke Sellström, was threatened with harm. Their convoy was shot at. But their 41-page report was completed in record time.

Sarin was that breed of accident that scientists come to regret. Its inventors worked on insecticides made from organophosphate compounds at the notorious IG Farben chemical company in Nazi Germany. In 1938, they hit on substance 146, a formula that caused massive disruption to the nervous system. The chemical name was isopropyl methylfluorophosphate, but the company renamed it sarin to honour the chemists behind the discovery – Schrader, Ambros, Ritter and Van der Linde – according to Benjamin Garrett's 2009 book The A to Z of Nuclear, Biological and Chemical Warfare. The chemical they created had the grim distinction of being many times more lethal than cyanide.

Substance 146 is not hard to make, but it is hard to make without killing yourself. There are more than a dozen recipes that lead to sarin, but all require technical knowhow, proper lab equipment and a serious regard for safety procedures. One major component is isopropanol, more commonly known as rubbing alcohol. Another is made by mixing methylphosphonyl dichloride with hydrogen or sodium fluoride. But methylphosphonyl dichloride is not easy to come by. Under the Chemical Weapons Convention it is listed as a schedule 1 substance, making it one of the most restricted chemicals in existence.

Last year, the US and other countries stepped up efforts to block sales to Syria of chemicals that might be used to make sarin. But the country had already amassed substantial stocks of the precursors needed to make the agent. This month, it emerged that Britain had approved export licences to Syria for the sale of more than four tonnes of sodium fluoride between 2004 and 2010, though business secretary Vince Cable said there was no evidence they had been used in the Syrian weapons programme. The exports came on top of sales approved last year for sodium and potassium fluoride under licences that were later revoked on the grounds that they could be used in the manufacture of weapons.

Though referred to as a nerve gas, sarin is a liquid at temperatures below 150C. To maximise its potential as a weapon, the substance is usually dispersed from a canister, rocket or missile in a cloud of droplets that are fine enough to be inhaled into the lungs. Inevitably, some evaporates into gas, much as spilt water turns into

vapour. The chemical enters the body through the eyes and skin too. Sarin has no smell or taste and is colourless, so the first people may know of its use is when victims start to fall.

Sarin takes such a dreadful toll on the body by interfering with a specific but crucial aspect of the nervous system. It blocks an enzyme called acetylcholinesterase, with devastating consequences. Nerves that usually switch on and off to control muscle movements can no longer be switched off. Instead, they fire constantly. There are mild effects: the eyes become irritated, the vision blurred; people's pupils shrink, they drool and vomit. Then there are the lethal effects. Breathing becomes laboured, shallow, erratic. Unable to control their muscles, victims have convulsions. The lungs secrete fluids and when people try to breathe, foam comes from their mouths, often tinged pink with blood. A lethal dose can be just a few drops and can kill in one to 10 minutes. If people survive the first 20 minutes of a sarin attack, they are likely to live.

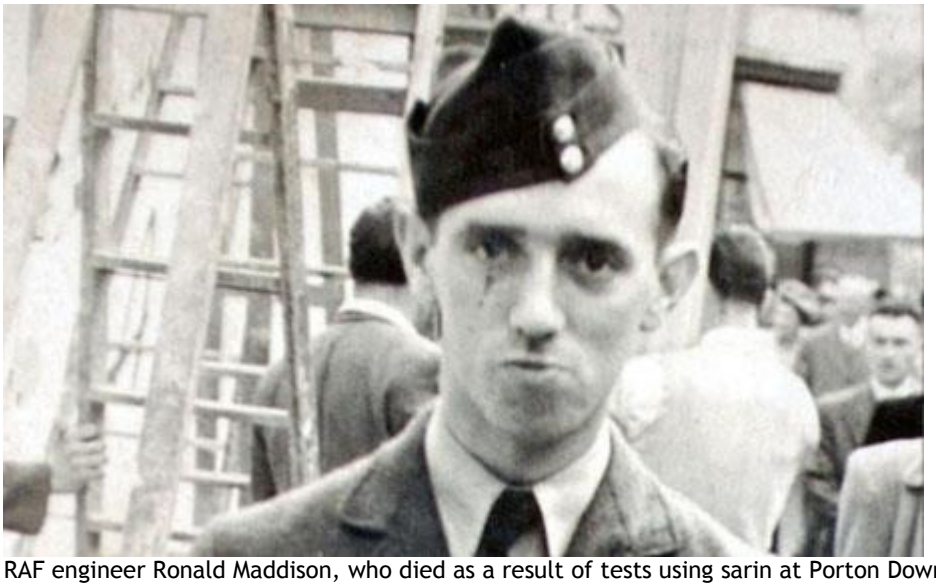
Soon after sarin was invented, the recipe for the agent was passed to the German army, which set about manufacturing stocks of the weapon. The agent was loaded into shells, but never used on Allied forces in the second world war. At Nuremberg in 1948, one of the inventors, Otto Ambros, was convicted of war crimes and sentenced to eight years in prison. He was released after four years, and whisked off to the US where he worked as a consultant on that country's own chemical weapons programme. In military circles, sarin came to be known by a secret name: GB.

A unique document from 1952, one year after Ambros arrived in the US, describes the gruesome effects of sarin poisoning after an unfortunate military accident. On the morning of 7 November 1952, a jet aircraft sped towards Dugway Proving Ground in Tooele, Utah. The sky was clear and the wind was a gentle breeze of 3-4mph. Each of the plane's wing tanks were filled with 100 gallons of sarin.

The plan was for the plane to spray the sarin over a target site, but because of a malfunction, each tank still contained 90 gallons of sarin when they were jettisoned in an isolated area of the site at 8.29am. The tanks fell from 2,000ft on to the salt crust of the open desert and burst open as they struck the ground. The sarin, dyed red to help gauge how far it had dispersed, was spread over 38,000 sq ft.

An inspection crew was sent out in an ambulance to investigate the site where the tanks had landed. Half an hour before arriving, they all donned gas masks. All except one 32-year-old man. He promptly climbed out of the ambulance and walked towards a crater made by one of the falling tanks. Within 10 seconds, he turned, clutched his chest and made quickly back to the ambulance. He called for his gas mask and stumbled. According to the report: "As he staggered, one arm extended and flexed in a jerky manner. He collapsed upon reaching the ambulance."

Medics swiftly administered a deep injection of atropine into the man's thigh. This is the standard antidote for sarin, and it works by blocking the agent's effects on nerves. As he breathed, he made screeching sounds and low-pitched gargles. He had rapid, violent convulsions for a minute, his legs and spine extending, his arms flung above his head. He then fell into a flaccid paralysis and stared straight ahead. Two minutes later he made only the occasional gulp for air. Soon his pupils were pinpoints. "No arterial pulse could be detected by the aid man," the report says.



RAF engineer Ronald Maddison, who died as a result of tests using sarin at Porton Down in 1953. Photograph: PA

The details of the exposure continue, recorded in minute, excruciating detail. Miraculously, the man survived after being hooked up to an "iron lung" resuscitator at a hospital. Nearly three hours after the accident, the report notes: "The patient appeared alert and oriented although he complained of severe malaise." The man held the unenviable title of the most severe sarin casualty of the time.

The US was not the only country to experiment with sarin in the cold war years. The USSR produced the agent for chemical warfare. And Britain took an interest too. A year after the incident at Dugway, a 20-year-old RAF engineer called Ronald Maddison took part in an experiment at Porton Down, the UK's chemical warfare facility in Wiltshire. At 10.17am on 6 May, Porton scientists dripped liquid sarin on to the arms of Maddison and five others who, for the scientists' safety, were held in a sealed gas chamber. Maddison fell ill and slumped over the table. He was taken to the on-site hospital but died at 11am. In 2004, more than 50 years later, an inquest found that the Ministry of Defence had unlawfully killed Maddison after one of the longest cover-ups in cold war history.

Accidents and unethical experiments gave only a glimpse of the horrors that scientists had made possible with the invention of sarin. In the hands of a nation's military, sarin and other agents were a means to kill swiftly such large numbers of people that the figures are quoted as rounded hundreds, even thousands. Saddam Hussein's bombardment of Halabja in northern Iraq lasted two days in 1988 and killed 5,000 people. The attack against the Kurdish people was recognised as an act of genocide by the Supreme Iraqi Criminal Tribunal in 2010. It was the largest chemical weapons attack against civilians in history.

In 1993, 162 countries signed the Chemical Weapons Convention, which outlawed the manufacture and stockpiling of chemical weapons. Gradually, nations began to destroy their stocks, itself a complex and dangerous task. Engineers came up with some blunt but effective ways of dealing with the problem. One is to strap explosives to rockets, shells or canisters filled with chemical agents and blow them up in an armoured blast chamber. Another is to burn the munitions in an armoured kiln. Stores of chemicals held in barrels are incinerated or "neutralised" by mixing them with other chemicals. Sophisticated facilities use airtight vessels and process their waste, but they are a luxury. In Iraq in the 1990s, chemical agents were mixed with petrol and burned in a furnace built from bricks in a trench in the desert.

The emergency service tend to victims of the Aum Shinrikyo sarin attack on Tokyo's subway in 1995. Photograph: Rex Features

The convention did not put the raw chemicals for sarin out of reach. Two years later, in 1995, the Aum Shinrikyo sect punctured bags of homemade sarin in the Tokyo subway. Though only a dozen people were killed, more than 5,500 sought medical help, the vast majority being the "worried well" who feared they had been exposed. The psychological impact did not end with the attack. Kenichiro Taneda, a doctor at St Luke's International Hospital in Tokyo, recalled the awful realisation that he would have to wheel a young woman who had died in the emergency department past a large crowd to reach the hospital mortuary. So as not to cause more worry he "transferred her by keeping an oxygen mask on her face and covering her body with a blanket".

Physicians who treated the victims of the Tokyo attack ran extensive tests to look for signs of sarin in blood, urine and other medical samples. The tests, and others developed by the military, have become standards for chemical weapons inspectors looking for evidence that sarin has been used.

Sarin itself reacts easily with water and so it breaks down when it meets rain, moisture in the air or sweat. The agent's fragility in water led hospital staff in Syria to uses hoses to drench rooms where they received victims after chemical attacks. For the same reason, sarin does not hang around for long in the environment, or in people. Laboratories can test for the substance, but more often will find breakdown products. The first substance sarin degrades into is isopropyl methylphosphonic acid (IMPA), which is generally regarded as proof positive for sarin. But IMPA itself breaks down, into methylphosphonic acid (MPA). Finding MPA in blood or urine is not a smoking gun for sarin: it can come from other organophosphates. Knowing which one matters.

The UN inspectors found concrete evidence that sarin was used with lethal effect in Ghouta on the outskirts of Damascus on 21 August. The team plans to go back soon, to visit Khan al-Assal, Sheik Maqsood and Saraqueb, before submitting a final report. That will end another grim chapter in the story of sarin, and open a new one focused on destroying the weapon.