A Dark Crystal, Rediscovered

Why was an insecticide more effective than DDT ignored for seven decades? A pair of chemists finds the answer in its surprising origins

Crystals are everywhere: in rocks, snowflakes, salt, sugar, commercial products like aspirin, even medical conditions such as gout and kidney stones. In fact, says Michael Ward, Silver Professor of Chemistry, crystallization is the third-largest industrial process in the country. And exploring that process is what compelled Ward and his fellow NYU chemistry professor Bart Kahr to begin researching the insecticide DDT. Little did they know they were about to go down a crystalline rabbit hole.

The research team initially undertook a study of the infamous mosquito killer "not because it was an insecticide but because it was a crystal," Kahr explains. Specifically, they were interested in crystals that twist as they grow, and DDT happened to be one of them. DDT was by then a "pariah substance" in most of the world, Kahr says, its environmental damage having been documented decades earlier by Rachel Carson in her book *Silent Spring*. But since it hadn't been studied in recent times, there was a lot to learn. Ward and Kahr discovered that the crystal structure of DDT was polymorphic, meaning that the crystals can take different forms. Ward compares the phenomenon to hats hanging on different racks—one with a square lattice of hooks and the other with a triangular lattice. "You'd have the same hats but they would be arranged differently." If the hats can be rearranged, different versions of a product are possible.

DDT is absorbed through the feet of insects when they walk on its crystals. Ward and Kahr wondered if different crystal forms could kill disease-carrying and crop-destroying pests before they reproduce and their offspring develop resistance. So they replaced two of DDT's chlorine atoms with two fluorine atoms. It's an obvious tweak, says Kahr, because chlorine and fluorine are in the same column in the periodic table. Tests of the resulting formulation, DFDT, showed it killed insects two to four times faster than DDT.

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As the chemists continued to explore DDT and DFDT, they made another extraordinary discovery: DFDT had already been created by German scientists during World War II. The Germans' goal was to build a better insecticide and to avoid having to pay a patent fee to the Swiss company that invented DDT. But regardless of motive, DFDT was the superior compound—a fact the world ignored for over 70 years.

"There was a distaste for German science," says Ward, "and probably a feeling that German science was inferior." Digging into the bowels of the Library of Congress, Kahr found "dismissive" post-war interviews of German scientists by British and US government officials who seemed intent on not facing the possibility that their former enemies had anything of value to contribute. And because DDT was already established by the time DFDT came to light, US companies, suggests Ward, "had a vested interest in keeping DDT alive and not following up on DFDT." He also notes that DDT might have had an economic advantage because chlorine is cheaper than fluorine.

Would things have been different if Americans had paid more attention to science, rather than politics, before more than 2 million tons of DDT were sprayed across the United States? "I can imagine that outcomes might have been very different, but for good or ill, [it] will remain a mystery," says Kahr. "There were no controlled trials of DDT versus DFDT." Adds Ward: "While the greater effectiveness of DFDT may result in less being used compared with DDT, we know nothing about the ecological consequences of using even a smaller amount."

DDT and DFDT continue to stir controversy. In 2017, the two professors published their first findings in the international journal *Angewandte Chemie*, along with an essay they wrote defending Rachel Carson against vicious attacks by deniers of climate change advocating for environmental deregulation. Then in 2019, the *New York Times* reported on the team's discovery of DFDT and its German background. The story referred to the insecticide's development as "Nazi" science and ran a misleading photo in its online edition of a concentration camp prisoner being deloused with DDT, which was used to protect against typhus, by a British liberator. Some readers were understandably unsettled. Kahr, who is Jewish, says he understands why emotions ran high but adds that "this was never a 'Nazi' insecticide. It was something that was used by the German armed forces" to protect troops against malaria on their far-flung campaigns.

Ward and Kahr, meanwhile, are carrying on their study of insecticides. By heating and cooling a commercially available form of deltamethrin, they have created a new crystallized form that is up to 12 times more effective against mosquitos. Their findings were published in the journal *PNAS*. "I don't want insecticides in the world," says Kahr. "On the other hand, it's unlikely we would be able to feed 8 billion people in the world right now without them. And we don't have another way of combating mosquito-borne infectious diseases effectively," including 400,000 malaria deaths every year, most of whom are African children. Figuring out how to use smaller amounts of insecticide more efficiently is key to saving more lives, he adds, "and maybe crystallography can play a role here. We think it's possible."

The chemists have now created a more effective crystal form of the insecticide deltamethrin.

Courtesy of Jingxiang Yang

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