

Ozone depletion: Uncovering the hidden hazards of hairspray

Science stories are all around us everyday—in the objects we use and the decisions we make—but they are often hidden. For example, it's easy to switch on a light or decide to wash your hands before eating without thinking about the scientific investigations that helped us understand electricity or germs. Science stories are even hidden in the rules and regulations that protect our safety. Here, we'll learn about the discovery that common household chemicals were destroying the atmosphere—and how this scientific research changed environmental policies all over the world . . .

CFCs are manmade chemicals that used to be common in refrigerators, Styrofoam, and aerosols. People thought they were harmless. But that started to change in 1970 when James Lovelock, a medical researcher, investigated the source of the haze near his home. Using instruments he designed himself, he detected CFCs in the haze, and to his surprise, discovered that CFCs were present even on clear days! He took his instruments on a boat trip to Antarctica and detected CFCs even far out at sea. Lovelock reported his discovery to the rest of the scientific community.

When the chemist, Sherwood Rowland, heard about this, he got curious too. He wondered what the effects of CFCs were on the atmosphere. Rowland decided to work on the problem with the chemist Mario Molina. Molina and Rowland didn't do any experiments or gather any data, but they did read as much as they could about other scientists' work on CFCs and the atmosphere. They began to look at the evidence in a new way and figured out how known chemical processes would work on CFCs. To their dismay, they found that, if all that they'd learned was true, sunshine could turn CFCs into ozone-destroyers—and each CFC molecule could destroy many, many ozone molecules! This was a major worry because the ozone layer in the atmosphere protects Earth from harmful radiation. They consulted a colleague about it and then decided to publish their work for other scientists to build on. They also told the media and politicians about their findings to try to encourage action on the problem—but there was still a lot that needed to be done to test Rowland and Molina's ideas.

Their main hypothesis was that CFCs were causing major ozone destruction, but this idea was based on many smaller hypotheses about the way that CFCs move through the atmosphere and the individual chemical reactions that occurred. Other scientists built mathematical models of the process—sets of equations that represent chemical reactions in the atmosphere. These models incorporated all of Rowland and Molina's smaller hypotheses.

The models suggested that, if the hypotheses were correct (and the ozone was being destroyed by CFCs), CFCs would be broken down at high elevations. Hence, the level of CFCs should drop off at the highest altitudes. In 1975, two different groups of scientists sent CFC-measuring tools up in airplanes and balloons. They found that CFC levels dropped off as predicted—supporting the ozone destruction hypothesis.

Despite this evidence, many people didn't want to ban CFCs because of all the businesses involved with making CFCs. CFC makers tried to cast doubt on the hypothesis any way they could.

Scientists, on the other hand, were starting to be convinced by the evidence and accept Rowland and Molina's idea. Still, Rowland and Molina kept trying to figure out if they might be wrong somehow. They ran some experiments about a chemical reaction that they had initially thought wouldn't make a difference in the process of ozone destruction. They found that the reaction was more important than they thought and reported this discovery to the rest of the scientific community.

Different groups of scientists incorporated the new discovery into their models of the atmosphere—but they got some surprising results. Some of the models continued to predict a big drop in ozone, but others predicted rising ozone levels! What was going on? They compared results and eventually figured out that some of the models were too simple: they assumed that the intensity of the sun is the same all day long—when it actually varies over the course of the day. The more accurate models predicted a drop in ozone. Even with the new chemical reaction factored in, the ozone destruction hypothesis held up.

Meanwhile, other scientists were working on gathering more evidence about the hypothesis. In 1976, scientist James Anderson announced that he'd sent sensitive instruments up into the atmosphere on a balloon and detected exactly

the chemicals we'd expect to find as the result of ozone destruction. After hearing about this and other evidence, the US government decided it was time to act. They announced a plan for phasing out CFCs—but the energy behind this soon fizzled and CFC production started to go up again.

Then, in 1982, researcher Joseph Farman independently noticed that the data he'd been collecting in Antarctica showed a big drop in ozone levels! The drop was so big, that at first he thought that his instruments were broken. To check, he compared his data to NASA's. Something was wrong. Farman's instruments seemed to be working, but his data didn't match NASA's. Eventually, they figured out that NASA's process for analyzing the data was faulty. When NASA scientists reanalyzed their Antarctic measurements, they discovered a gigantic hole in the ozone layer the size of the United States! Why was the ozone destruction happening so much faster over the Antarctic than any of the models had predicted?

Atmospheric scientists Susan Solomon and Rolando Garcia thought the unusual ice clouds at the Poles might have something to do with it. They reasoned that the icy clouds might speed up the reactions that destroy ozone. They contacted Rowland to see what he thought. Rowland, Solomon, and Garcia started working together on the problem. Experiments supported the idea that ice could speed the reactions, and when the ice clouds were factored into the models, the models predicted much bigger drops in ozone—more like what Farman had observed in the Antarctic.

This inspired other scientists to work on the problem too. They discovered many different lines of evidence suggesting that the chemical reactions hypothesized by Rowland, Molina, Solomon, and Garcia really were occurring and that the icy clouds sped up the process at the Poles. But there were still some loose ends to tie up. Though ozone was decreasing at the Poles, no decrease in ozone over the rest of the planet had been detected. NASA organized a special panel to look into the conundrum. The 150 scientists on the panel eventually figured out that there had been a problem in the analysis of the atmospheric data. Ozone levels were actually decreasing all over the planet.

This was finally enough to inspire real policy changes. In 1990, governments from all over the world agreed to phase out CFCs. Now our hairspray, refrigerators, and other products are CFC-free. With the CFC-ban in place, the ozone layer should be on its way to recovery. Rowland and Molina were awarded a Nobel Prize for their work on CFCs—but their work depended on other members of the scientific community. As with many scientific triumphs, this success belongs to no one person, but to the whole scientific community—and to the broader community, which acted on important scientific findings.