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RETROSPECTIVE

# F. Sherwood Rowland (1927–2012)

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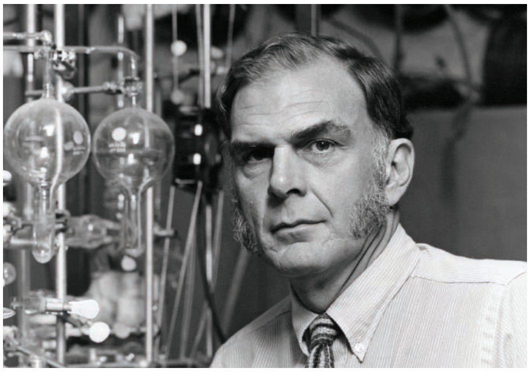
A Nobel Prize–winning atmospheric chemist instrumental in discovering and publicizing the role of chlorofluorocarbons in ozone destruction.

F. Sherwood ("Sherry") Rowland died on 10 March at age 84. He was a distinguished scientist, first in physical chemistry and radiochemistry as a hot-atom chemist and later as an atmospheric chemist (*1*). He was also famous for his leadership in discovering and publicizing the danger to the ozone layer posed by continued human release of chlorofluorocarbons (CFCs).



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The research that led Sherry Rowland to become a public figure began with curiosity. In the early 1970s, CFCs were an industrial success story as near-ideal refrigerants and as propellants in many aerosol-spray products. At a 1972 Atomic Energy Commission conference, Rowland heard that James Lovelock had detected CFC-11 in air over the North and South Atlantic Ocean. Rowland wondered what would eventually happen to this synthetic chemical in the atmosphere. In 1973, one of us (M.J.M.) joined Rowland at the University of California (UC) at Irvine. As chemists, Rowland and Molina knew that CFCs had been designed to be inert and nonsoluble and were, thus, unlikely to be decomposed by common atmospheric processes. However, they realized from laboratory data and chemical insight that the CFCs would be decomposed by ultraviolet light (wavelengths below 220 nm) in the upper atmosphere, above much of the ozone layer.

Rowland and Molina continued their detective work, asking what would become of the fragments of CFCs: carbon, chlorine, and fluorine atoms. They discovered that chlorine attacks ozone catalytically and that continued release of CFCs into the atmosphere could destroy substantial amounts of the global ozone layer. After confirming that there were no errors in the calculations, they publicized these results at a press conference in September 1974, soon after their first paper on the topic was published. In his many subsequent interviews and public appearances, Rowland was unfailingly polite and clear, and he never exaggerated. Consequently, his credibility grew.

A great deal of media and public attention in CFCs ensued, especially between 1974 and 1978, including hearings in state legislatures, city councils, and the U.S. Congress. While Cicerone and Molina testified at a number of these hearings, Rowland was particularly generous with his time when asked for comments or advice by legislators who were considering laws or regulations concerning the production, sale, and distribution of CFCs.

During this time of intense public debate, Rowland and Molina discovered a complication to the originally proposed chemical mechanism by which chlorine would destroy ozone: It became clear that chlorine nitrate would form in the atmosphere, thereby linking reactions of chlorine oxides and nitrogen oxides. This insight led to a brief period of uncertainty about the impact of CFC-derived chlorine on ozone, due to two factors: The three-molecule reaction rate to form chlorine nitrate in the lower stratosphere was not known with sufficient accuracy, and the mathematical techniques in use at the time in some mathematical models were unsuitable. Both issues were resolved within a few months. It was extremely important that this modification to the originally proposed reaction scheme was introduced by Rowland and a colleague (M.J.M), not by a critic of the theory.

By the time the Antarctic ozone hole was discovered in 1985, Rowland had already raised the idea that hydrogen chloride and chlorine nitrate were unlikely to undergo only gas-phase reactions; laboratory studies had shown them to be "sticky," surface-reactive chemicals. Later, surface reactions of these two chlorine-containing species were shown to be responsible for releasing active chlorine into the Antarctic stratosphere and destroying ozone.

In many public appearances, Rowland presented his case that continued use of CFCs would greatly diminish the ozone layer, thereby increasing the intensity of biologically damaging ultraviolet light at Earth's surface. He was always up-to-date scientifically, and he showed his data: Those who opposed him had few easy opportunities to discredit him. He also became very active in evaluating atmospheric ozone data, searching for the predicted decreasing trends. With his students, including one of us (D.R.B.), he published analyses of air samples from all over the word, showing that atmospheric methane concentrations were rising.

Sherry Rowland contributed enormously to the public understanding and credibility of science. Along the way, he was President of the American Association for the Advancement of Science (1993 to 1994); the AAAS building reflects his work with its designers. He insisted on a human-friendly design and no CFC-based refrigerants. He also served as foreign secretary of the U.S. National Academy of Sciences (1994 to 2002), was instrumental in starting the field of atmospheric chemistry, and was a founding faculty member of UC Irvine. In 1995, he was awarded the Nobel Prize in Chemistry (with Paul J. Crutzen and Mario J. Molina). His many friends treasured his affinity for operatic music, his interest in sports (he had played semiprofessional baseball and basketball), and his occasionally memorable jokes.

Sherry Rowland's engaging personality was obvious, but nowhere more so than in a tense 1986 U.S. Senate hearing. Asked what he would do, if he were king, about the widespread usage of CFCs in light of their threat to stratospheric ozone, he replied, turning to his wife, Joan: "I would ask the queen."

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**References and Notes**

1. See www.uci.edu/features/2012/03/feature_rowlandobit_120311.php for a slideshow in memory of Sherry Rowland's life and work.

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