

Charles J. Pedersen, Nobel Chemist

Charles J. Pedersen, A Remarkable Scientist

Early in 1967, a paper from Charles J. Pedersen, a chemist at the DuPont Experimental Station, landed on the desk of the editor of the *Journal of the American Chemical Society*. The paper was unusual for several reasons, not least of all its sheer volume - when published it ran 20 densely printed pages. It represented more than five years of laboratory work accomplished entirely by Pedersen with the assistance of a single technician, Ted Malinowski. In the paper, Pedersen reported the discovery of a novel class of chemical compounds called macrocyclic polyethers, which he dubbed the "crown" ethers because of their molecular shape.

The journal's distinguished editor, Marshall Gates, wrote to Pedersen saying, "You are quite clearly reporting monumental piece of work which we shall be quite happy to publish." Both Gates and the still-anonymous referee who reviewed the paper pointed out that many researchers would have managed half a dozen articles out of a similar quantity of data.

For Pedersen, who freely admits he disliked writing papers, one was enough. Although he later published some follow-up papers, the original article, "Cyclic Polyethers and Their Complexes with Metal Salts" [*J. Am. Chem. Soc.* 89, 7017 (1967)] has since become known to Pedersen's colleagues simply as "the blockbuster."

It was the capstone of a successful career. Pedersen retired from DuPont with considerable fanfare two years later. After that, things quieted down. "Charlie," as he is called by friends, spent his retirement gardening, fishing, birdwatching and writing poetry.

But other chemists began to build on his discovery and such work began to snowball. In August of 1987, a symposium on crown ethers was held in Japan in Pedersen's honor, and it appeared he was at last getting overdue recognition - at least from scientists in his field.

And then came the phone call from Sweden.

On the morning of October 14, 1987 an undersecretary of the Nobel foundation called to tell Pedersen that he would share the 1987 Nobel Prize for chemistry.

"I was flabbergasted," Pedersen said at a press conference later that day.

Anyone who knew Pedersen could appreciate the sincerity of his surprise. Even in his later years, his health impaired by cancer, he had lost none of the gentle, unassuming and sensitive nature that endeared him to friends and colleagues over the years. He was a brilliant chemist with the soul of an artist - a man who admitted he would have been as content to paint watercolors as do chemical research. Former chairman Richard E. Heckert called him a

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"chemist's chemist - a man of unusual curiosity and keen ability to see simple solutions to complex problems, often when others missed them."

Al MacLachlan, DuPont senior vice president for technology at that time, acknowledged that "the company's entire research community was uplifted by the news that Charlie Pedersen won the Nobel. It represents a vote of confidence in the way we go about doing research. There are several other technical developments underway in the company that could lead to similar recognition in the future, and would be nice if Charlie's prize could some day be looked upon as the first of several."

In hindsight, it is easy to believe that Pedersen was destined to make some phenomenal discovery. He had a penchant for being in the right place at the right time. "When I was working at Jackson Lab, I used to go one day a month to the Experimental Station. Once while I was there, I saw Julian Hill mixing a solution in a test tube. He pulled out the rod from the tube and with it came many strong fibers." It was historically the first example of cold drawing a synthetic fiber, a technique which later became the process for making nylon and Dacron® polyester fibers.

On another day at Jackson Lab, where Roy Plunkett's laboratory was across the hall from Pedersen's. "I saw Plunkett's technician, Jack Rebok, open a cylinder. On the inside was a white substance along the rim." It was Teflon® fluorocarbon resin," Pederson said.

A few years down the road, in another lab, it would be Pedersen's turn.

Charles Pedersen, the Path to a Nobel Career

Pedersen was born in 1904 in Korea, the son of a Norwegian father and a Japanese mother. His father was a maritime engineer who later was hired as a mechanical engineer by Oriental Consolidated Mining Company, an American concern that ran the Unsan gold mines in the northern part of Korea. According to Pedersen, childhood at Unsan was exciting, reminiscent of the American West.

At the age of eight he was sent abroad to Japan for schooling, first at a convent school in Nagasaki, and two years later to a French-American preparatory school in Yokohama run by the Marianist order of Catholic priests and brothers. As he approached college age, the Marianists steered Pedersen to the order's University of Dayton in Ohio.

After receiving a degree in chemical engineering from Dayton, Pedersen went to MIT for a master's degree in organic chemistry. He was urged by his advisor, James F. Norris, to

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pursue a doctorate. Pedersen declined. He had been sending bills home to his father for too long and wanted to go to work. Also, he admits candidly that "I was no great lover of formal education; I didn't look forward to several more years of schoolwork."

Professor Norris contacted colleagues at DuPont to tell them they should consider hiring one of his especially bright students. They did, and Pedersen reported to the Chambers Works' Jackson Laboratory in Deepwater, N.J., in 1927. He didn't leave until 32 years later when he transferred to the Experimental Station for the last 10 years of his 42-year DuPont career.



Pedersen's mentor at Jackson Lab, William S. Calcott, recognized something special in his new employee from the start, and Pedersen wasted no time in confirming this judgement. One of his earliest accomplishments - and the one that had the most commercial impact - was the discovery of a dramatic improvement in the process for making tetraethyl lead, for many years an important gasoline additive. Then during the 1930s, Pedersen discovered the first deactivators to counter the degradative effects of heavy metals in gasoline, oils and rubbers. This insight also had considerable commercial value. Next, Pedersen researched degradative oxidation of petroleum products. In the space of 10 years he became the inventor or coinventor of 30 patents for antioxidants and other products.

In 1946, Pedersen was promoted to research associate, then the company's highest research position, which enabled him to pick his own projects.

In 1957, the Organic Chemicals Department was divided into two departments, one of which was Elastomers. Pedersen had the option of remaining in Orchem or going with Elastomers. He chose Elastomers in a decision that reveals much about his character.

"I hated to drive," he said, "and I know that if I chose to stay with Orchem, I could continue to work at Jackson Lab which was only 15 minutes from my house in Salem (N.J.). If I went to Elastomers, I would have to drive all the way to the Experimental Station near Wilmington, Del., each day. But I said to myself that it was not moral to make my decision on that basis alone. So I went with Elastomers because I knew the people who would be managing the research, and I knew that they really wanted me to go with them."

At the Experimental Station, Pedersen reported to Herman Schroeder, and conducted several original investigations in a field not familiar too him, namely hydrocarbon polymers. In 1961, Schroeder suggested that he return to his field of expertise --- the catalytic action of trace heavy metals and their control by use of organic ligands. He decided on a systematic

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study of complexes of vanadyl ion (VO) with multidentate phenolic ethers both as polymerization catalysts and for deactivating residual pro-oxidant vanadium in the polymers. In one of his reactions, he was left with a "brownish goo." In his initial attempt to recover his desired product, he discovered some unknown crystals as a byproduct. He studied the crystals and was intrigued by their properties.

Pedersen was startled to learn that any methanol-soluble salt with sodium would enable the crystal to dissolve in methanol. But why? Pedersen soon found out. The molecular weight of his crystal was exactly twice what he had predicted. "That was the 'eureka' moment," Pedersen said. "The molecular structure of the crystal was ring-shaped and the sodium ions had fallen into the hole in the center of the molecule and been held there."

Pedersen named his compound a "crown" ether because the official names "were so complex and hard for me to remember." He chose "crown" for aesthetic reasons as well. The molecules were not like a necklace that has to open to be put on or taken off. Rather, they were like a crown since they maintain their unbroken structure during reactions.

Pedersen embarked on an exhilarating period of research into this new uncharted territory of chemistry. He was openly appreciative of his DuPont managers for encouraging him to pursue these studies, even when it was apparent that they would yield little of immediate commercial value. "I think it is important for people to know that DuPont gave me nine years to do this work, which was an opportunity that I might not have gotten elsewhere," Pedersen said.

He was also quick to point out that he accomplished his most important work late in his career. "It tends to be said that the best work performed by scientists is done by the time they are 35 years old," he says. "This work was done during my last nine years at DuPont. It capped my career."

Pedersen was the first career DuPont scientist to win a Nobel Prize.

What is a Crown Ether?

A crown ether is a molecule containing hydrogen, carbon and oxygen atoms. Each oxygen atom is bound between two of the carbon atoms and arranged in a ring (hence "crown").

The original crown ether discovered by Charles Pedersen has six oxygen atoms exposed along the inside wall of the ring. When atoms of certain metallic elements such as sodium or potassium pass through the center of the ring, they attach themselves to the exposed oxygen atoms and fit like a key in a lock.

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The crown compound then acts as "host," taking its "guest" to a place where it would not otherwise go - for instance, through the membrane that forms the wall of a cell. The high degree of selectivity enables the crown compound to "identify" the guest atom in a solution and wrap around it.

In accepting specific atoms lock and key fashion, crown ethers mimic in a relatively uncomplicated way the very complicated functions of biological materials such as enzymes. It is this mimicry that has scientists so excited. The study of crown compounds may indicate new approaches for developing pharmaceutical systems or a way to cross the blood-brain barrier. They may help explain how the body moves sodium and potassium, essential elements for life, into cells.

Crown ethers also have potential to be used as "scavengers" to remove certain elements like radioactive strontium from the environment or to regulate concentrations of sodium in the blood. Some people have even suggested that crown compounds could be used one day to extract uranium or gold from seawater.