George Andrew Olah

(1927–2017)

Hydrocarbon chemist whose work changed fuels, materials and drugs.

George Olah transformed the understanding of organic chemistry and reactions. His Nobel-prizewinning work on carbocations — generally unstable chemical species in which a carbon atom bears a positive charge — led to applications including better oil and gas refining, new methods for synthesizing small molecules and the discovery of drugs and materials.

Olah, who died on 8 March, was born on 22 May 1927 in Budapest. He attended the Gymnasium of Piarist Fathers, a Catholic teaching order that emphasizes classics, history, languages, liberal arts and philosophy. He finished school while the Second World War was raging. In his autobiography, *A Life of Magic Chemistry* (2nd edn, Wiley, 2015), he described some horrifying experiences: living in hiding, losing his brother to a Russian prisoner-of-war camp and clearing rubble in his bombed city.

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After the war, Olah studied organic chemistry at the Technical University of Budapest. He completed his doctorate in 1949 under Géza Zemplén, a former student of Nobel-prizewinning chemist Emil Fischer. In the same year, he married Judith Lengyel, his partner in research as well as in life. He began his career at the Technical University as an assistant professor, and in 1954 became head of organic chemistry and associate scientific director at the Central Research Institute of the Hungarian Academy of Sciences in Budapest.

The post-war years were hard. After the failed Hungarian uprising against Soviet rule in 1956, the future looked bleak. Olah fled his native country with Judy and their toddler son, George, in search of a better life. (As did around 200,000 other Hungarians.)

In 1957, Olah joined the Dow Chemical Company in Sarnia, Canada. At that time, the company was manufacturing polystyrene using a reaction (the Friedel–Crafts type electrophilic substitution) that involved carbocations. This was where Olah achieved his breakthrough in producing long-lived carbocations, the work won him the Nobel Prize in Chemistry in 1994.

At Dow, Olah had realized that 'superacids' — billions, even trillions, of times stronger than 100% sulfuric acid — can stabilize carbocations. In 1965, he became a professor at what is now Case Western Reserve University in Cleveland, Ohio. There, a lab member decided to try such an acid on a Christmas candle. As if by magic, it cleaved the wax into long-lived carbocations. In subsequent papers, Olah called the substance magic acid.

Before Olah's work, carbocations were known only as fleeting intermediates existing for microseconds or less in acid-catalysed transformations. Olah stabilized them and so elucidated their structure using low-temperature nuclear magnetic resonance (NMR) spectroscopy, and later using X-ray analysis. His genius paved the way to an understanding of hydrocarbon reaction mechanisms, which in turn led to improved processes for refining oil and gas.

Olah proposed a clear demarcation between 'trivalent' carbenium ions (for example, CH_3^+), in which the positively charged carbon centre forms bonds with three other groups, and carbonium ions (such as CH_5^+), in which the carbon forms bonds with five or more other groups. He showed that the two types of ion are both intermediates in electrophilic reactions, but in different ways. (The former involves electrons donated from π orbitals, as found in double bonds, and the latter involves donations from σ orbitals, a 'non-classical' situation in which two electrons are shared by three atoms.) This important distinction had not been previously established.

Olah's work overturned the long-held assumption that a carbon atom could bind to no more than four other atoms. He proved the existence of the 2-norbornyl cation, a non-classical ion proposed by his friend Saul Winstein. Olah used low-temperature NMR and superacids to establish the non-classical structure of this carbocation at the centre of the debate over classical ions and non-classical ions.

Olah's studies on compounds containing carbon atoms with more than four bonds led to a new area of 'hypercarbon chemistry'. He extended the types of reaction that were possible by showing how to activate electron-seeking species, or electrophiles, into superelectrophiles. His work on fluorine chemistry helped thousands of researchers to study and develop many fluorinated pharmaceuticals. About 25% of all drugs currently on the market are fluorinated compounds.

In 1977, Olah moved with his group to the University of Southern California in Los Angeles, where he founded the Loker Hydrocarbon Research Institute. His post-Nobel research with long-time collaborator Surya Prakash focused on green fuels derived from carbon dioxide capture and recycling. In particular, they worked on methods to convert natural or shale gas efficiently to methanol, a clean-burning renewable liquid fuel that can be used in place of petrol and diesel, and as a feedstock for petroleum-derived products. Carbon dioxide is now converted to methanol commercially at the George Olah Renewable Methanol Plant near Grindavík, Iceland.

George was a visionary and his breadth of knowledge was immense. After reports that carbon ions had been observed in space, he suggested that methanol could have had a key role in the evolution of complex building blocks of biology, and eventually of life.

He was a hero of chemistry, a role model and a caring human being. As one of his colleagues, chemist Chi Mak, said, he had the "audacity to imagine the unimaginable, think the unthinkable and to dream the impossible". ■

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