The World of Chemistry Since George Olah until Today

Miklos Simonyi

Abstract - **The driving force of scientific endeavor, the realization of incomprehensible for George Olah is contrasted to present-day research atmosphere including applications, subscriptions, libraries and social matters.**

Index Terms - **Adherence to subject, recognition of unknown, role of education, signs of deterioration.**

I. Introduction

After World War II, the first sensation people felt in most European countries was their survival. Next, they started to ensure everyday life. Third, they tried to look into the future. In 1945, this was certainly the case for young George Olah in heavily destroyed Budapest after the siege of the Soviet Army that terminated the Nazi and fascist periods. Olah, then 18, just finished Gymnasium of the Piarist Fathers, a Roman Catholic religious teaching order [1]. It was a famous and very good school emphasizing mainly humanities (classics, history, languages, philosophy). Although this school had been attended by the famous physiscist Lorand Eotvos (whose name has been given to one of the largest Hungarian Universities) and the Nobel-prize winning chemist, George Hevesy (1943), they were not mentioned the students as models [1]. Olah did not receive initiation towards chemistry either from childhood, or through education. When he chose chemical engineering at the Technical University of Budapest, his choice was mainly motivated by the belief that it would offer better living opportunities than any subject of the humanities.

II. Olah's World of Chemistry

University studies for Olah gave solid foundation for organic synthesis and some of his professors induced interest and love for chemistry, however the newer trends of chemistry received little attention [2]. Olah developed the habit of spending long hours in the University library, where he learned new vistas. In 1949 he completed studies and found an assistant professor faculty position in the organic chemical institute led by the famous chemist, Geza Zemplen, a former student of Emil Fischer. Zemplen brought home Fischer's traditions and interests in natural products, especially carbohydrate chemistry and established the first organic chemistry institute at the Technical University in 1913. Olah started working in carbohydrate chemistry, but very soon developed his own interest in fluorine chemistry. His first papers in this subject appeared in the Hungarian periodical Acta Chimica [3-5]. In the 1950s, it was an important though mainly technical field. Olah's real fascination came from the Friedel-Crafts reaction; he simply could not understand how it proceeded.

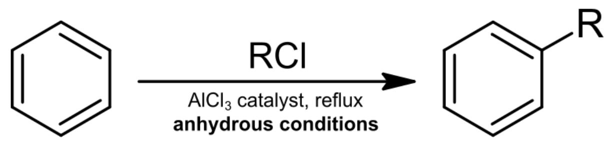

Figure 1. The Friedel-Crafts reaction

The $AlCl_3$ catalyst, a Lewis acid, prefers to take up another chloride ion and form an aluminate in which the electron-deficit is compensated. But how could an alkylchloride provide chloride ion? Should it form a positively charged carbon? That was the beginning of his scientific path and continued by his efforts to understand it. His realization that a stronger Lewis acid could shed new light on the problem led him to apply his new achievements of fluorine chemistry. He changed $AlCl_3$ to BF_3 and ensured inactive medium to prevent decomposition of the presumed ionic intermediate. By this way he was able to isolate for the first time arenium tetrafluoroborates of ionic nature without being able to perform their structural study.

$$ArH + HF + BF_3 \rightleftharpoons ArH_2^+ BF_4^-$$

$$ArH + RF + BF_3 \rightleftharpoons ArHR^+BF_4^-$$

Figure 2. Alkylation and acylation with BF_3

The primary activity for Olah – from the beginning of his career – had been research that earned him high reputation and received invitation to become deputy director in a research institute of the Hungarian Academy of Sciences. Regardless of his position, he remained adamant in his efforts to understand the reaction mechanism, a central problem of physical organic chemistry. Although he had to leave his native country in 1956 and found a new way of living for his family by working in an industrial laboratory (Dow Chemical) and later as Professor of chemistry at Western Reserve University, his scientific effort to prove the existence of positively charged carbon had remained the same. By the 1970s his group had developed such a powerful experimental capacity that enabled them to produce positively charged carbon in virtually all kinds of molecules. Figure 3 illustrates reaction paths leading to a carbonium ion, while Figure 4 and 5 demonstrate the multitude of carbocations and carbodications they were able to produce [6].

Miklos Simonyi, Institute of Organic Chemistry, Research Centre for Natural Sciences, H-1519 Budapest, P.O.B. 286, Hungary

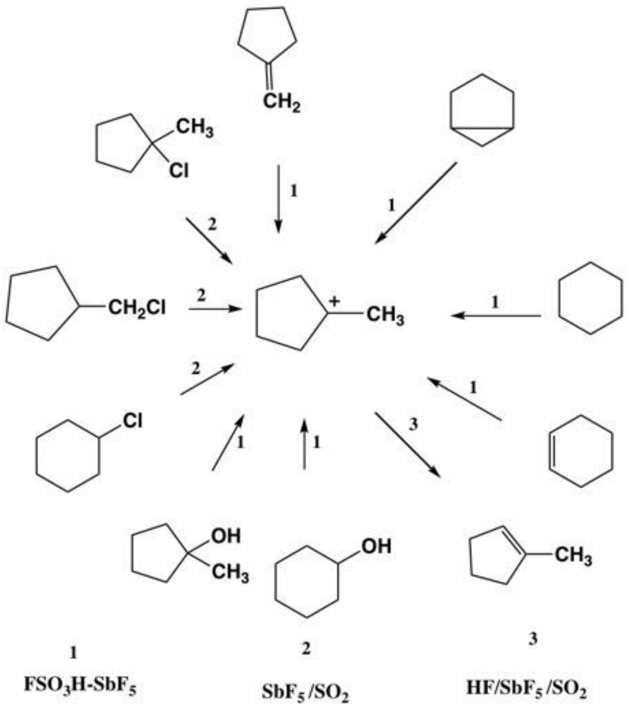

Figure 3. Reaction paths leading to stable carbonium ions.

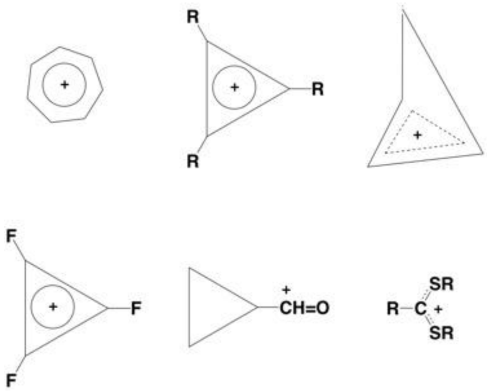

Figure 4. Stable carbocations

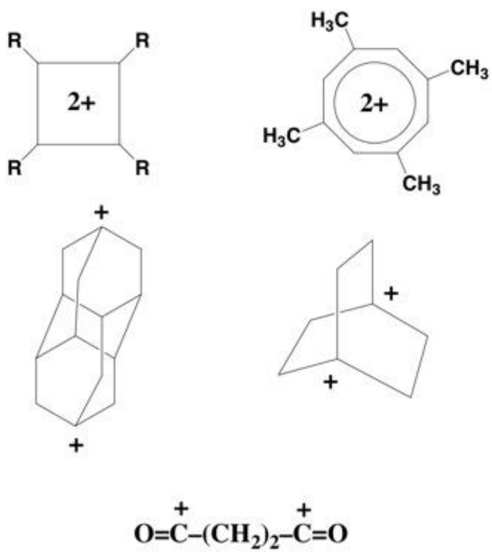

Figure 5. Stable carbodications

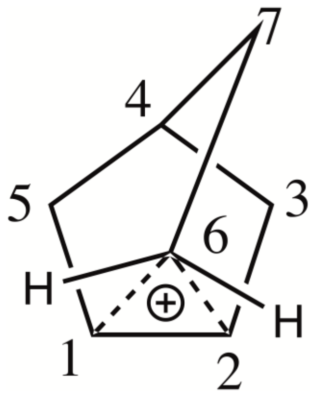

Figure 6. The carbon numbered 6 has five neighbors

The possession of such skills, enabled Olah to solve the heavily debated structure of the norbornyl cation [7]. This was the first proved example of a carbon atom having five neighbors (Figure 6).

Olah then established two different classes of carbocations, namely the trivalent, *sp2*-hyridized, electron-deficient *carbenium* ions, and the penta-coordinate carbonium ions representing two-electron three-center bonding [8].

Olah soon started to apply the acquired scientific achievements for practical solutions. He founded the Loker Hydrocarbon Institute in the campus of the University of Southern California (USC) and used the carbocations to form branched hydrocarbons that eventually led to the production of unleaded gasoline. In 1994, Olah received the Nobel-prize for Chemistry as sole recipient, but did not want to change his life-style and rest on his laurels. Another of his ambitious ventures was to spare natural hydrocarbon resources (petroleum oil) and replace it with methanol produced from methane and carbon dioxide. As a result of his efforts during the last twenty years of his career, the World's largest CO_2-to-methanol plant was named after him and began production in Svartsengi, Iceland in 2012. It earned him and his coworker, Surya Prakash another distinction, the Samson prize, for reducing the global dependence on oil.

III. COMPARING CONTEMPORARIES

Having been a native Eastern-European, one may speculate how much Olah could have achieved had he remained at home. A valuable comparison offers itself by comparing his career with that of a worthy contemporary, Arpad Kucsman. In 1945, then 18 too, Kucsman just finished the Fasori Gymnasium ran by the Lutheran Church. This was another famous school, where John von Neumann, Eugene Wigner (Nobel-prize for physics, 1963) and John Harsányi (Nobel-prize for Economics, 1994) had learnt from a legendary teacher of mathematics and physics, Laszlo Ratz. Kucsman – a generation younger – had another excellent teacher of physics, and mathematics, Miklos Vermes, who provided a very good education in chemistry, too. Vermes helped him to get admission to the famous Bolyai College that enabled him to obtain free position at the Budapest Pazmany University of Science (Eotvos Unversity today). Kucsman chose chemistry as his favorite subject.

He enjoyed good teachers in the University of Science, completed his studies in 1949 and obtained a position in the institute of organic chemistry led by a new professor Gyozo

Bruckner. The professor's main field was peptide chemistry, but – first of all – he was an excellent lecturer. Kucsman was appointed as lecture assistant and made detailed notes during the professor's lectures. By the end of the first year these notes amounted to a thousand pages and formed the basis of the first volume of Bruckner's organic chemistry handbook. Over the years the book developed to a 6-volume set and became used by generations of chemists and pharmacists. Kucsman remained editor and later became coauthor of the venture. Besides his primary work in education, Kucsman did research too, and – like Olah – tried to find his own field. While working on Bruckner's handbook, Kucsman realized, he did not understand the stereochemistry of sulfur-organic compounds. Bruckner agreed with his doubts and encouraged him to work in this direction. His publication on that subject appeared in Acta Chimica [8] in the same issue that contained Olah's first papers on fluorine chemistry. Kucsman's paper was the start of sulfur-organic chemistry that later produced valuable results [9].

In 1956, the two men decided differently: Olah leaved the country to prevent political retaliation, while Kucsman had no such fear. His career was very successful in national standards. In 1970 he became successor of Bruckner and served until 1993 as head of the Organic Chemistry Institute. He received several distinctions, at one time the two men could even clink their glasses (Figure 7).

Figure 7. Olah (left) and Kucsman when the latter received the Golden Medal of Eotvos University

Olah fully acknowledged the high level of Hungarian education providing basis for many talented scientists. He personally knew several of his contemporaries who had not left the country and could not carry out what they could have achieved. A small, isolated and poor country has not provided possibility for that [10]. Nevertheless, something is common for both men: they started their career by realizing something incomprehensible, the most powerful driving force for the scientific endeavor.

IV. THE WORLD OF SCIENCE TODAY

There is a proliferation in the number of people doing research, hence science is transforming from vocation to profession. As a consequence, the creation of committees, i.e. bodies responsible for arranging competition for applicants took place on international level. They formulate aims the applicants should approach and manage the applications to be judged in order to decide which of them should have the merit to be supported financially. The possibility of travelling, and contacting colleagues abroad are – by all means – much better today than were 70 years ago. Internet networks within seconds allow exchanging information with research groups located on the other side of the globe. Still, our world of science has several problems.

The application system – even if absolutely unbiased and ethical – does not harmonize with scientific interest. The applicant should describe not only the aim of research but also the results to be achieved. There is no way to put forward one's interest generated from something unknown, or unintelligible. The applicant cannot indicate he/she still has no idea what will find in the literature by the help of which the task can be solved. A better prospect can be envisaged by „*lying some beautiful*" that compromises the applicant's ethical standards. Sometimes it is compulsory to indicate some partner of collaboration, a misunderstanding of research itself. Collaboration is indispensable means of science, but not the aim. In most cases the need of collaboration emerges in the course of research work, and obviously be realized even if it was not apparent at the time of application. Sometimes applications invited to address severe problems society is faced to (e.g. health care, famine, epidemics), which are only camouflage for economical or political incapability. Thus, requirements toward the applicant represent rather the concepts of the members of the committees who mostly have stopped practicing research activity. Many good scientists today contribute only to, or cooperate with someone whose subject is supported. Only a few can claim original research. Young Olah could have small chances by indicating his interest in isolating ionic intermediates.

With increasing expenses of scientific journals, the economic management of scientific establishments requires online subscriptions and discontinues, sometimes even demolishes libraries. This fervor is harmful. The online search is fast and useful, indispensable for the scientist. But when someone does not know what to search and gives only a chance to find something important, a library is better. Series of monographs display the development of a subject starting from the work of pioneers, who probably suspected, but did not know for sure the results of the field they started. Here again, the interest generated from unknown or incomprehensible phenomena is lost if we have only the internet. And – last not least – online accessibility is vulnerable and may be stopped by technical failure, or sabotage.

V. REQUIREMENTS THE SCIENTIST IS FACED TO

A common place often heard in interviews by scientists that they are happy because could work along their delight. It is seldom to hear about difficulties in private life, a real challenge encoded in devoted scientific work. Allen characterized the research in chemistry, as follows:

„. . . any scientific study begins with facts in which observers can agree. Facts give rise to hypotheses that suggest controlled experiments designed to yield further facts, and in turn to generate new hypotheses. From data established progressively in this cyclic way generalizations are induced and subjected to further critical experimental test. The useful generalizations, the principles, the theories of science, are those emerging temporarily triumphant from these never-ending attempts to disprove them. In seeking these generalizations, the aim is to be able to predict the behavior of a particular system, be it a mechanism, a chemical reaction, or a physical transformation, which has not itself been studied experimentally" [11].

A scientist absorbed in such an activity has to exclude all kinds of sentiment, and should heavily rely on experimental facts. Outside the lab he/she might be boring and lack spare time for family, or partner in life. Perhaps this may be a reason why men outnumber women in science rather than mental strength, since women are as clever as men.

Our characters treated here were exempt from such problems. They were both well-educated, cultured people. Olah married at the age of 22 and found his wife to be a partner for life. Kucsman has never married, so could not annoy his family.

VI. THE END OF THE PATH

After a long and extremely successful life with full of work, Olah died at his home on March 8, 2017. The USC News issued a deserved farewell of him [12]:

„Olah was born in Budapest, Hungary, in 1927. He showed no interest in chemistry during his formative years. Instead, he followed a strict and demanding curriculum that heavily emphasized the humanities, including eight years of Latin and obligatory German and French. That stayed with him later in life, when he became known in academic circles as a Renaissance man. Olah was a firm believer in goal-oriented research, and his studies during his 40-year career at USC were distinguished by their immense practical applications. He made significant contributions to the development of improved lead-free gasoline, cleaner high-octane gas and other promising nonpolluting fuels, as well as many chemical processes now used in pharmaceutical and industrial chemistry. He developed new methods to convert existing natural gas (methane) directly and efficiently to methanol. However, the true methanol economy, Olah argued, will do without fossil fuels like natural gas, oil and coal, instead producing methanol by the reaction of hydrogen with carbon dioxide collected from exhaust gases from power plants and various industrial emissions. Eventually, Olah proposed, it will be possible to separate atmospheric carbon dioxide and convert it to methanol, enabling mankind to liberate itself from dependence on fossil fuels." [12]

Figure 8. In memoriam: Nobel laureate George Olah, 89, USC News

During his career, Olah authored or co-authored 20 books and close to 1,500 scientific publications. He held 160 patents from seven countries, including four for the transformation of natural gas into gasoline-range hydrocarbons.

He is survived by his wife, Judith Olah; their sons, George Olah Jr. '89 MBA and Ronald Olah '85 MD; daughters-in-law, Sally Olah and Cindy Olah; grandsons Peter Olah '16 BS and Justin Olah; and granddaughter Kaitlyn Olah.

But this is not the end of the story. According to Olah's last wish, his ashes were transported to his native city, Budapest, and his funeral – with all due solemnity – took place on September 19, 2017 in the Kerepesi Graveyard.

Figure 9. Olah's ashes

Figure 10. The grave of Olah

Having been forced to leave his native country, he gave new land to his sons, but returned home.

REFERENCES

[1] G. A. Olah, A Life of Magic Chemistry, Wiley Interscience, 2001, p. 41.
[2] p. 48, in Ref. 1.
[3] Gy. Olah and A. Pavlath, A new method for the preparation of aliphatic fluorine compounds, *Acta Chim. Acad. Sci. Hung.*, 1953, **3**, 196-197.
[4] Gy. Olah and A. Pavlath, The preparation of 2-fluoro-ethanol, *Acta Chim. Acad. Sci. Hung.*, 1953, **3**, 199-202.
[5] Gy. Olah and A. Pavlath, The preparation of fluoromethanol, *Acta Chim. Acad. Sci. Hung.*, 1953, **3**, 203-207.
[6] pp. 94-95, in Ref. 1.
[7] M. Simonyi, The legacy of George Olah, *Period. Polytech. Chem. Eng.,* 2017, **61,** 301-307.
[8] G. A. Olah, General concept and structure of carbocations based on differentiation of trivalent (classical) carbenium ions from three-center bound penta- or tetracoordinated (nonclassical) carbonium ions, *Journal of the American Chemical Society*, 1972, **94,** 808–820.
[9] A. Kucsman, Über den Bau optisch aktiver Schwefelverbindungen, *Acta Chim. Acad. Sci. Hung.*, 1953, **3**, 47-55.
[10] F. Ruff and A. Kucsman, Mechanism of the reaction of sulphides with N-chloro-arenesulphonamides, *J. Chem. Soc., Perkin Trans. 2*, 1975, 509-519.
[11] pp. 222-223, in Ref. 1.
[12] J. A. Allen, Energy Changes in Chemistry, Allyn and Bacon, Boston, 1966, p. 1.
[13] https://news.usc.edu/