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Professor Junji Furukawa

Professor Junji Furukawa is celebrating his 87th birthday on December 18, 1999. He is recognized internationally as one of the most productive polymer scientists that Japan has ever raised. His fields of work have been wide, ranging from polymer synthesis and polymerization catalysis to rubber stabilization and polymer rheology. It is gratifying that he is still active in the theoretical aspects of this last field.

Junji Furukawa was born in Osaka in 1912, the year when Emperor Meiji, the 122nd Emperor of Japan, passed away. He attended a middle school of commerce in Osaka, and aspiring to become a scientist, he entered the Kyoto Imperial University. He majored in applied chemistry in the Faculty of Engineering and graduated from the University in 1937.

Immediately after graduation he was appointed Instructor at the Department of Industrial Chemistry of Kyoto University and started research work on synthetic rubber under the guidance of Professor Gen-itsu Kita. He first established a new method for the preparation of butadiene from acetylene by vinylacetylene as an intermediate. He became Associate Professor at the Chemical Research Institute of Kyoto University in 1940. One of his first major contributions was the invention of a method for preparing the copolymer of butadiene and methyl vinyl ketone, a copolymer which was excellent as an oil-resistant synthetic rubber. For this invention he was awarded a prize from the Japanese Government in 1943. He also received the degree of Doctor of Engineering from Kyoto University in the same year and was promoted to Professor at the Research Institute in 1948. His lifelong position as a rubber specialist was established by this time.

In 1950 Dr. Furukawa was appointed Professor at the Faculty of Engineering of Kyoto University. He was in charge of a research group in polymer synthesis at the Department of Industrial Chemistry. His best known achievement there is probably the synthesis of polymers from oxiranes and aldehydes[1] using aluminum and zinc alkyls, modified with water or other reagents, as catalysts. These catalytic systems have often been referred to as the “Kyoto catalysts” or the “Furukawa catalysts”. Polymers of ethylene oxide, propylene oxide, and epichlorohydrin were thus prepared,[2] and acetaldehyde, acetone, and ketene as well as their nitrogen and sulfur analogues were also polymerized[3] with these catalysts. The method was further extended to the preparation of new polymers from four- and five-membered ring compounds such as lactones, lactams, and sulfides. In an extension of these studies, boron alkyls used in the presence of oxygen were found to be excellent catalysts for the radical polymerization of vinyl monomers.[4]

In 1960 Professor Furukawa was instrumental in founding a new chemistry department, the Department of Synthetic Chemistry, at Kyoto University, where he established a new research group devoted to polymer-

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ization chemistry. Oxirane polymerizations were studied extensively, but his particular interest in butadiene polymerization was renewed here with an additional objective of achieving full structural control of the polymers prepared. Thus, he succeeded in the preparation of *cis*-1,4-polybutadiene, an analogue of "synthetic natural rubber", with a new nickel catalyst.[5] Alternating copolymers of butadiene with propylene and acrylonitrile were synthesized with modified Ziegler−Natta type catalysts.[6,7] These copolymers proved to be excellent rubbers having high tensile strength due to strain-induced orientation.

In parallel with the work in polymer synthesis, several different types of studies were also pursued. Thus, the protection of rubber from oxidation and ozonization was a subject of intensive study,[8,9] giving results that were of practical value in the stabilization of rubber. Mechanistic considerations of the catalytic activity of organometallic reagents (e.g., the concept of enantiomorphic catalyst sites[10] and the model of back-biting coordination of polymer ends onto the metallic centers[11]) served as a guide for understanding the mechanism of stereoregulation in polymerization reactions. Also, some unique types of organic syntheses using organometallics as catalyst (e.g., the modification of the Simmons−Smith reaction to achieve a more efficient formation of the cyclopropane ring using zinc or cadmium alkyl[12] and the dimerization of butadiene into methylenevinylcyclopentane with a nickel catalyst[13]) were reported.

After 39 years at Kyoto University, Professor Furukawa retired from the University in 1976, but he soon initiated investigations in theoretical chemistry of the rheological behavior of polymeric materials. The study was continued throughout the period of his subsequent professorships at the Aichi Institute of Technology and the Science University of Tokyo.

He retired from these two institutions in 1986, but his fascination with polymer rheology continued. The key point of his interests was the role of possible entanglement of polymer chains to form networks of the segments through cross-linking by cohesion.[14,15] Formation and rupture of these pseudo cross-links are regarded in his treatment as the principal factors governing the rheological behavior of polymers. His thermodynamic and kinetic treatments give information on the size of these links, the length of network chains, and both the glass temperature and softening temperature and can explain almost all of the rheological characteristics, such as stress-relaxation spectra and viscoelasticity, of elastomers. Tack adhesion and friction can also been explained quantitatively.[16] His study in this theoretical field is still continuing and will become an important part of his life work.

Besides all of the scientific contribtions described above, Professor Furukawa fulfilled significant administrative roles in the chemical community. He was an organizer of the International Rubber Congress in Tokyo in 1975. He served as President of the Society of Polymer Science in Japan in 1976−1977 and of the Japan Chemical Society in 1978. He received many awards, both domestic and worldwide, among which were the Colwyn Medal of the British Rubber and Plastic Institute in 1977 and the Witco Award of the Polymer Chemistry Division of the American Chemical Society in 1978. Additional details of Professor Furukawa's career have already been described in a recent biography.[17]

One characteristic feature of Professor Furukawa's activities has been his emphasis on "motivation". Meditation or "to keep thinking" has always been an absolute must in the Furukawa group, and any motive arising from enthusiastic thinking was always welcome, even when it was somewhat illogical. Experiencing this sort of atmosphere was a great privilege to the members of his laboratory.

The long-standing scientific activity of Professor Furukawa is admirable. To congratulate him on it, a large number of his former group members still often get together with him. It is hoped that Professor Furukawa will enjoy many nice returns of such events together with his wonderful life partner, Mrs. Nobu Furukawa.

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