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## 15. Clement Henry Bamford

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## Personalities in Polymer Science



Clement Henry Bamford\*

Clement Bamford was and is one of the leaders in Polymer Science in England and highly regarded world-wide. His contributions to radical polymerization are numerous and fundamental. For many years he was the most prominent figure of Macromolecular Chemistry in IUPAC.

Clement Bamford was born in Stafford, England on October 10, 1912. He was the only child of Frederick Jesse Bamford and Catherine Mary Bamford, née Shelley. His father was an accountant, the son of the congregational minister at Launceston, Devon. His mother was the daughter of a farmer near Stafford.

Stafford, where Clement grew up, was a typical country town, the administration center of the county. It had about 30,000 people in those days. As a child his earliest memories go back to the name Bam, which was probably the first word he could say. He is still known as Bam having been called that name at home, at school and at the University.

Bam attended the St. Patricks Catholic School, where he was captivated by chemistry; much of his time at home was spent doing experiments and writing "text books". In 1923 he obtained a county scholarship to King Edward VI School, Stafford. Here he obtained several prizes

and finished up in 1931 with awards which enabled him to proceed to Trinity College, Cambridge.

At Trinity he took Chemistry, Physics and Mathematics in the Natural Sciences "Tripos", graduating with first class honors. He then joined the research group of the famous Professor R. G. W. Norrish (later Nobel Laureate in Chemistry) and duly obtained a Ph.D. with a thesis entitled "The Chemistry of Carbonyl Compounds". On the basis of his thesis, Bamford was elected to a Prize Fellowship at Trinity College, lasting four years, with no special duties. He started work on the properties of nitrogen compounds and published a few papers, but the Second World War intervened and Bamford was assigned to the Special Operation Executives. He visited corresponding stations in the U.S.A.

After the war, in 1945, Bamford decided to go into industry and joined Courtauld Ltd., a manufacturing organization mainly involved in textiles, which was establishing a new Fundamental Research Laboratory in Maidenhead. Bamford started up this laboratory and became its Head in 1947.

He received the Sc.D. (Cambridge) in 1958.

In 1962 Bamford was invited to and accepted a position of Cambell Brown Professor of Industrial Chemistry at the University of Liverpool. In his academic life at the University of Liverpool, he served as the Head of the Department of Inorganic, Physical and Industrial Chemistry from 1973 to 1978, as the Dean of the Faculty of Science from 1965 to 1968, as a Member of the University Council in 1968 and from 1972 to 1978 as the Pre-Vice Chancellor. In 1980, Bamford retired and became Professor Emeritus.

Retirement did not prevent Bamford from continuing his scientific activities. In 1980, on the invitation of the then director Dr. D. Annis, he joined the Bio-engineering and Medical Physics Unit (later the Department of Clinical Engineering) of the University as an Honorary Senior Fellow, and worked until 1996.

Over the years, Clement Bamford was active as a Visiting Professor and lecturer. In 1977 he was a Visiting Professor at Kyoto University and in 1990 at the

University of New South Wales in Australia. Clement Bamford was main lecturer in Europe, the U.S.A., U.S.S.R., Japan, India, China and Australia.

Clement Bamford was very active in Professional Societies. On the local level, he was the first chairman of the Thames Valley Section of the Royal Institute of Chemistry (1956-58) and also of the Liverpool and Western Section (1968-69). From 1960 to 1965 he was a Member of the Council and later Vice-President of the Faraday Society. In the Chemical Society he was a Member of the Publication Committee (1960-1965); in the British Association for the Advancement of Science, he was President of the Section B (Chemistry), (1976-1977), and in the Royal Society a Member of the Sectional Committee 3, which considers for election candidates in Chemistry, Applied Chemistry and Theoretical Chemistry (1972-1974).

Bamford was highly engaged in the Macromolecular Section of the International Union of Pure and Applied Chemistry (IUPAC). From 1974-77 he was a UK National Representative, from 1977 to 1981 the Vice President and from 1981 to 1985 its President.

Bamford's research can be divided into four parts: The Cambridge period, the Courtauld period, the Liverpool period and the "Retirement" period.

The Cambridge period was characterized by photochemistry of carbonyl compounds. He investigated the Norrish II rearrangement, the photochemical reaction first observed with simple aldehydes and ketones, leading to disruption of the carbon chain ( $\alpha,\beta$ ) without the intervention of free radicals.

At Courtauld, the general aim was to produce a "synthetic silk from  $\alpha$ -amino acids. Two major problems were involved: the production of polypeptides of sufficiently high molecular weight and spinning the product into fibers. The polymerization of N-carboxy- $\alpha$ -amino acid anhydrides [Leuchs anhydrides] of glutamic acid and alanine was very extensively studied. It was an extremely fruitful field which produced many interesting kinetic results, e.g. the Chain Effect. Of great interest also was the recognition of the  $\alpha$ - and  $\beta$ - form of the

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## Columns

polypeptides and their interconversion. During the whole time at Courtauld he was also involved in free radical research, especially the measurement of the absolute rate coefficients in free radical polymerization and the behavior of radicals in heterogeneous systems.

Bamford's research in Liverpool encompassed numerous subjects, including ESR, initiating systems of various kinds, solid-phase polymerization, block and graft copolymers, polymer networks and studies on reaction mechanisms. Among these areas of interest, the study of initiators played the primary role. One major case investigated was based on metal carbonyls. Type I arises when the metal (in a low oxidation state) reacts thermally or photochemically with an organic halide (the co-initiator). Electron-transfer from the transition metal to the halide occurs, cleaving the halide into an ion and a radical. When the co-initiator is a polymer with multiple halide groups a graft copolymer is formed.

A completely different type of initiation, Type II, occurs when the co-initiator is an olefin with electron-attracting groups or acetylene or a substituted acetylene. The polymeric products contain covalently bound terminal metal atoms, which, above 100 °C yield radicals capable of forming block copolymers. Extensions led to the preparation of so-called "polyfunctional macroinitiators". Many graft and block copolymers were prepared by these methods.

In his later years Bamford, in the Department of Clinical Engineering, became interested in biological systems: Antiplatelet agents, e.g. prostaglandins and "BW 245C", potentiation, water soluble and insoluble systems, anticoagulants (e.g. heparin), polymer surface functionalization, membranes showing molecular recognition, and non-classical free-radical polymerization including Group-Termination procedures were all subjects of interest.

Bamford's work was published in 320 papers, 20 reviews and 2 books, "Synthetic Polypeptides" in 1956, and "The Kinetics of Vinyl Polymerization by Radical Mechanisms" in 1958.

As the case for many very active scientists, Clement Bamford was also active in publication. From 1969 to 85 he was the co-editor of *Comprehensive Kinetics* (26 Volumes) and he is on the Editorial Board of *Polymer*. He was the

Founding Editor of *Biomaterials Science* and was formerly on the Editorial Board of *Biological Macromolecules* and *Photochemistry*.

His scientific and personal accomplishments were recognized by a number of Honors and Awards. In 1964 he was elected a Fellow to the Royal Society. He received honorary doctoral degrees from the University of Bradford (1980) and from the University of Lancaster (1988).

Other Awards included: the Meldola Medal of the Royal Institute of Chemistry (1941), the Award in Macromolecules and Polymers from the Royal Society of Chemistry (1977), the Award for Distinguished Services in the Advancement of Polymer Science from the Society of Polymer Science, Japan (1989) and in 1996 the Honorary Membership of the Society. In 1992 he received the George Winter Award of the European Society for Biomaterials. He is a Life Member of the Society for Chemical Industry and Royal Society of Chemistry, UK.

When asked which hobbies Bam has he will say: music, gardening and hill-walking. His real love was, however, playing the violin. He began, interested in listening to the leader of a small orchestra in the local cinema at the age of 7. Soon thereafter he began taking lessons from well known violinists, Arthur Hytch and Arthur Catterall and to travel weekly to Manchester for lessons. In Cambridge he continued lessons with Catterall, who was by now the leader of the BBC Symphony Orchestra in London. He took advantage in Cambridge of the eminent violinist Max Rostal to study further. He played at many concerts, especially those arranged by the University Music Society, and led the University Orchestra. His favorite composers were Mozart, Brahms, Bach and Franck.

In Maidenhead there were more opportunities for playing. In Liverpool he played the Bruch concerto with the student orchestra and also gave a recital with Basil Smallman, the Professor of Music. At his retirement symposium in Liverpool in 1980, Stephanie his daughter and Bam played the C. Franck A major Sonata.

In 1938 Bam married Daphne Ailsa Stephan, who had obtained a B.Sc. from the University of Sydney and a Ph.D. from Cambridge. They have two children, Stephanie Catherine who is an accomplished pianist and has four children