BIOGRAPHICAL MEMOIRS

Alan Carrington CBE. 6 January 1934 — 31 August 2013

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Elected FRS 1971

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Alan Carrington was an outstanding physical chemist who made important contributions to molecular spectroscopy. During his distinguished career in the universities of Southampton, Cambridge and Oxford he was a pioneer in the fields of electron paramagnetic resonance spectroscopy of doped single crystals, solutions of organic radicals, and especially the high-resolution spectroscopy of gaseous free-radicals and ions. He wrote three books and was an excellent teacher and lecturer. His honours included the Davy Medal, the Faraday Medal of the Royal Society of Chemistry, and election as a Foreign Associate of the National Academy of Sciences.

EARLY LIFE AND EDUCATION

Alan Carrington was born in the winter of 1934 in Greenwich, a historic town on the Thames east of London. He was the only child of Albert and Constance Carrington. Albert came from the Yorkshire/Derbyshire area and was an orphan at the age of three years. He had little education but could read and write; he was working in a coal mine at the age of 13 years. He served throughout World War II as a soldier, was evacuated with the British Expeditionary Force from the beaches of Dunkirk in June 1940 and then joined the Eighth Army in North Africa. He studied and became expert in postage stamps, budgerigars or whatever caught his interest, a trait that would be reflected in his son.

Alan’s mother, Constance Carrington (née Nelson), was one of six children who grew up in east London. Her education was basic but she had an unshakeable faith in the value of education. She worked in a zip factory and was an expert knitter, winning several prizes. Alan and his mother did not see Albert for five years during the war. His childhood, like that of
many of his contemporaries, was dominated by the harsh realities of war. He was evacuated with thousands of other children from London during the Blitz; his good fortune was to live with his mother for five years with a loving family, the Cliftons, in Godmanchester, west of Cambridge. The Cliftons had a son of similar age to Alan. He attended a small primary school and was taught by two teachers, evacuees from London, Miss Harbord and Miss Thornton. Miss Harbord was the headmistress and told Constance that ‘Alan definitely has a brain!’ On Sundays he and his mother attended St Mary’s Church and he was much taken with the organ; his lifelong interest in music began in Godmanchester, as did his love of fishing and of the English countryside. At the end of the war in 1945 Alan took the ‘11-plus’ exam and passed, so he could proceed to a grammar school. He and his mother returned to London.

He started at Colfe’s Grammar School, a boys’ school, in the autumn of 1945 in temporary buildings in Lewisham, a suburb in southeast London, a six-mile train journey from home in New Eltham, near Greenwich. Colfe’s was founded in 1652 and its original buildings had been destroyed in 1944 by a ‘doodlebug’ (V1 flying bomb). His academic performance was ‘middle of the road’, his best subjects being history and geography. His mathematics teacher, Mr Birnberg, was superb but Alan found the subject difficult. His O-level examination performance was respectable and Alan wanted to continue into the sixth form. His mother was supportive but his father was unsympathetic. Mr Birnberg came to the family home, argued with Alan’s father and won, so Alan stayed on at Colfe’s and took chemistry, physics and mathematics at A-level. His results were good enough to take him on to the next stage of his education. He was active in sport at Colfe’s, became a member of the first rugby XV and was captain of the first cricket XI in his final year (figure 1). He was a batsman and wicketkeeper. He continued to enjoy sport in his later life.

Out of school, Alan’s most important interest was undoubtedly music. He joined the choir of Holy Trinity Church in Eltham and came under the influence of Bob Stainton, who was
the organist and choir master and a much respected friend. That friendship was to last for a decade. He and Alan would play piano duets in the Carrington home and Alan learnt much about organ playing. He succeeded in playing, for the cost of £1 per hour, the organ of the Royal Albert Hall in London.

Southampton University, 1952–59

Alan was determined to go on to university and applied to Southampton to read for an honours degree in chemistry. He sat a scholarship examination and was awarded an Exhibition that contributed £50 per year to his income. A State Scholarship provided all university fees and an annual maintenance grant. He left home in September 1952 and moved into South Stoneham House, a university hall of residence and a former stately home with the river Itchen running through the grounds. The hall held about 70 male students, and the university had just over 800 students. Southampton University obtained its Royal Charter in 1952, so Alan was part of its first intake of students.

The head of the Chemistry Department, and Alan’s first tutor, was Professor N. K. Adam FRS, a distinguished surface chemist. At the end of his first term, Alan was top of the examination list—his first such success. His interests in chemistry leant towards the small-molecule physics end of the subject. His affection for quantum theory was stimulated by the lectures and book of Dr Edward Cartmell and Dr Gerry Fowles. Throughout his undergraduate career he came top, or nearly top, in the examinations in chemistry and in his subsidiary subjects, mathematics and physics. His final examinations were taken in June 1955 and Alan was surprisingly placed on the border of a first-class and upper-second-class degree. The external examiner, Professor F. S. (later Lord) Dainton (FRS 1957), conducted an oral examination that did not embrace Alan’s strengths; he was awarded an upper-second-class degree, much to the surprise and disappointment of the staff of the Chemistry Department. He was nevertheless awarded the department’s premier research studentship, enabling him to continue in the department as a research student.

Alan joined the research group of Dr M. C. R. Symons (FRS 1985), a young lecturer in the Department of Chemistry who was collaborating with Dr D. J. E. Ingram, a lecturer in the Electronics Department and a pioneer in the field of electron paramagnetic resonance (EPR) spectroscopy, the technique that would raise Alan to the apex of physical chemistry when he applied it to highly reactive gas-phase free radicals. Alan set about seeking to understand the intense colour of transition-metal oxyions as in potassium permanganate and potassium manganate. The latter, which is obtained from the former by reduction in an alkaline solution, is a deep emerald-green colour; its MnO$_4^{2-}$ anion has an unpaired electron and so could be studied with EPR. Alan succeeded in growing single crystals of potassium chromate (K$_2$CrO$_4$) containing 1% of the magnetic potassium manganate (K$_2$MnO$_4$). Commercial EPR apparatus was still a long way off and Alan was excited to work with apparatus that was entirely home-built. The manganate anion exhibits fast spin–lattice relaxation, so it was necessary to cool the sample to very low temperatures to obtain a spectrum; this was achieved, with some danger, with liquid hydrogen. Alan’s first two scientific papers were published in *Journal of the Chemical Society* in 1956 (1, 2)*. Dr Ingram and Dr D. Schonland, a lecturer in the Mathematics Department, were vital contributors to the second paper. The research showed

* Numbers in this form refer to the bibliography at the end of the text.
that the intense colour of potassium permanganate is due to a charge-transfer transition in which an electron moves from an orbital delocalized over the four O atoms to a degenerate orbital localized on the Mn atom.

After just two years of research at Southampton, Alan went to the University of Minnesota to oversee the laboratory of Dr John Wertz, who was in Oxford on sabbatical leave. The laboratory contained excellent nuclear magnetic resonance and EPR spectrometers, both home-built, and Alan was let loose on them for a year. The Wertz laboratory was where he began his independent career by studying the EPR spectra of aromatic ions in solution (3). He was fascinated by proton hyperfine structure in organic free radicals, an interest that remained with him throughout his career. After a year in Minneapolis, Alan returned to Southampton to finish his PhD thesis, entitled ‘The electronic structure, spectra and properties of transition metal oxyanions’. Alan wrote to Professor Christopher Longuet-Higgins FRS in Cambridge enquiring whether he could spend a year in the Theoretical Chemistry Group in Cambridge and was delighted to be offered a postdoctoral fellowship funded by General Electric.

In his second postgraduate year in Southampton, Alan joined the University Operatic Society, accompanying singers on the piano. In 1956 the opera was Gilbert and Sullivan’s Patience and the leading role was sung by Hilary Taylor from Bristol, an undergraduate in the English Department. Alan fell in love with her at once and they began a relationship that was to last for the remainder of Alan’s life. They were married in the Priory Church of St James in Horsefair, Bristol, a Grade I listed building, on 7 November 1959.

**Cambridge, 1959–67**

Alan moved to Cambridge in August 1959. He joined Christopher Longuet-Higgins, Frank Boys (FRS 1972), John Griffith, Leslie Orgel (FRS 1962), Andrew McLachlan (FRS 1989) and John Murrell (FRS 1991) in the Theoretical Chemistry Group in the Department of Organic and Inorganic Chemistry of Cambridge University (John Pople FRS, Nobel laureate 1999, had left the Group in 1958 for the National Physical Laboratory). The department head was Sir Alexander (later Lord) Todd FRS (PRS 1975–80; Nobel laureate 1957), and Professor Harry Emeléus FRS was the Professor of Inorganic Chemistry. The department moved to a new building in Lensfield Road in 1958 and shared the building with the Department of Physical Chemistry, whose head was Professor R. G. W. Norrish FRS (Nobel laureate 1967). Alan knew of Andrew McLachlan, for Andrew worked with Martyn Symons in Southampton in 1957–58; it was their interaction in Cambridge that convinced Alan that he needed to know more theory.

Christopher Longuet-Higgins had decided that some experimental work would not be out of place in the Theoretical Chemistry Group, so he and Alan submitted a joint application for funds to purchase a Varian EPR spectrometer. While waiting for the result and then for the equipment, Alan wrote a review article on the EPR spectra of transition-metal ions (4). Christopher’s influence on Alan was profound. He hugely admired Christopher’s talents as a theoretician and as a musician. When the spectrometer arrived, Alan continued his work on aromatic radicals and radical ions. His research students included Jorge dos Santos Veiga (who later became Vice-Rector of Coimbra University in Portugal), Jim Bolton, Ray Golding, Peter Todd and Ian (I. C. P.) Smith (who became Director of the National Research Council Molecular Biophysics Laboratory in Winnipeg, Canada). Among the discoveries made during
this work was the hyperfine line-width alternation in the durosemiquinone cation, which turned out to be due to intramolecular motion causing isomerization between *cis* and *trans* forms (5, 6). Another novel result was the observation of free-radical partial alignment in a nematic liquid crystal, work carried out with Geoffrey Luckhurst (7).

In 1960 Alan was appointed to the university position of Assistant in Research (and later an Assistant Director of Research) and he was elected to a Research Fellowship (and later to a teaching Fellowship) in Downing College. In the next few years he was awarded the Harrison Memorial Prize, the Meldola Medal and Prize, and the Marlow Medal. Overseas trips were becoming a regular part of Alan’s life, as were invitations to lecture at British universities.

The arrival in 1964 of Don Levy from Berkeley as a postdoctoral fellow and Terry Miller from the University of Kansas as a research student provided the impetus for experimental work on small free radicals in the gas phase. The first system studied was a mixture of chlorine and oxygen flowing through the resonant cavity in a quartz tube; the researchers were immediately rewarded with a beautiful spectrum of the ClO radical (8). This was soon followed by other diatomic radicals (10). Thus began a Carrington legend, which would be augmented—in Southampton—by the arrival of John Brown (FRS 2003) and Brian Howard.

In 1966 Alan had the opportunity to spend a few months with Jim Hyde at Varian Associates in California. Together they developed a new microwave cavity that had particularly large entrance and exit holes. It greatly enhanced the gas-phase work and proved to be valuable for studying much larger solid-state samples. It formed the basis of Varian’s later electron–nuclear double resonance (ENDOR) cavity.

Alan and Hilary’s three children were born in Cambridge: Sarah in 1962, Rebecca in 1964 and Simon in 1966. All three became successful musicians. Music figured hugely in both Alan’s and Hilary’s lives in Cambridge. They were members of the Cambridge University Musical Society choir and Hilary was much in demand as a soloist in college concerts. Alan enjoyed his teaching duties, and his popular final-undergraduate-year course on magnetic resonance led to the publication, with Andrew McLachlan, of his first book, *Introduction to magnetic resonance* (9). Alan’s research in Cambridge and Southampton on the intricacies of the interactions in open-shell molecules led to his second book, *Microwave spectroscopy of free radicals* (14).

**Southampton, 1967–84**

Alan was appointed to a new Professorship of Chemistry at his alma mater, the University of Southampton, in 1965 but did not take up the chair until 1967. He was able to take his laboratory equipment with him and it was installed successfully in the old Assembly Hall with much help from Terry Miller and Brian Howard. John Brown rejoined the group as an ICI Postdoctoral Fellow in 1968 and became a lecturer and Reader before moving to Oxford in 1983.

Alan’s research continued to prosper in Southampton. High-resolution electron resonance studies were extended to triatomic radicals such as NCO, which provides an interesting example of the Renner effect, where electronic degeneracy of the linear structure leads to a coupling of the motion of the electrons and nuclei, something that is absent in the Born–Oppenheimer approximation (11). The first spectrum of a nonlinear triatomic radical, HCO, with fine and hyperfine structure was reported (12, 13). Alan’s attention was turning towards the spectroscopic study of gaseous ions: in 1977 he and Peter Sarre published a paper on the
spectrum of CO⁺ (15) and in 1978 on the sub-Doppler laser spectroscopy of molecular ions in ion beams (16). Rich vibrational spectra of the simple diatomic, HD⁺ (17), and of the simplest triatomic, H₂⁺ (18), were obtained, posing a significant challenge for theoretical chemists.

Recognition of Alan’s distinction came with the Royal Society of Chemistry’s Award in Structural Chemistry and the Tilden Lectureship and Medal, and in 1971 with his election to the Fellowship of the Royal Society at the very young age of 37 years. In 1976 Alan was appointed to the first Senior Fellowship of the Science Research Council, a five-year position that enabled the holder to concentrate on research. Among the members of his group were Juliet Buttenshaw, Peter Sarre and Tim Softley.

In 1979 Alan was appointed to a Royal Society Research Professorship, which gave him the freedom to concentrate on research, rather than on administrative matters in the university. He was to hold this prestigious position until his retirement 20 years later.

Oxford, 1984–87

After 17 years as Professor of Chemistry at Southampton, Alan was thinking about a move; Oxford was attractive because two of his former research students, John Brown and Brian Howard, were members of staff in the Physical Chemistry Laboratory (PCL), and the head of that Laboratory, Sir John Rowlinson FRS, made it clear that Alan would be welcome in the PCL. The Royal Society agreed that his Research Professorship could be transferred. The move to a laboratory on the second floor went smoothly and Alan found the department exhilarating. He was appointed to a Fellowship at Jesus College and lived there in a small room from Mondays to Fridays. Although he was very happy in the college, living in Oxford during the week and in Chandler’s Ford near Southampton at the weekend was far from ideal. Hilary had been appointed Lending Librarian at Fareham Public Library in 1984 and the prospect of finding a similar position in or near Oxford was not good.

Alan was thinking about some new experiments aimed at obtaining the electronic spectrum of the hydrogen molecule ion, H₂⁺—the simplest molecule. Apparatus was designed and built but the early experiments were not successful.

Two major honours were awarded to Alan while at Oxford: he was elected a Foreign Honorary Member of the American Academy of Arts and Sciences in 1987, and in 1985 he received the Faraday Medal of the Royal Society of Chemistry—the Society’s premier award in physical chemistry, made every third year.

The difficulties coming from living five days per week away from his family finally persuaded Alan to return to Southampton, so after three years in the PCL he went through the complicated process of transferring his equipment back to the Assembly Hall in Southampton, a move that was facilitated by two students, Christine Montgomery and Iain McNab, who continued their research in Southampton.

Return to Southampton, 1987–99

The new experiments on the hydrogen molecule ion that had been designed in Oxford had immediate success in Southampton. It was a beautiful result: a single-line spectrum arising from an electronic transition in the heavy-hydrogen molecular ion D₂⁺ (19). Characteristically
eschewing the routine, Alan turned his ion spectroscopy studies towards the precise measurement of ion-beam spectra of highly excited electronic states of HD⁺, excited vibrational states of the simplest polyatomic molecule H₃⁺, and ultrahigh-resolution spectra of other simple ions (20). Electric-field dissociation was used to state-select the very weakly bound near-dissociation levels of molecular ions (21). These experiments presented a daunting challenge to theorists, requiring the abandonment of the usual simplifying assumptions in the Born–Oppenheimer approximation. Alan judged his work on the hydrogen molecular ion and on similar molecular systems to be the best of his scientific career, and it continued until his retirement in 1999. The microwave experiments were extended to heavier ions such as He…Ar⁺ (22) and He…H₂⁺ (23).

In 1992 Alan was awarded the Davy Medal of the Royal Society, and in 1994, much to his and Hilary’s delight, he was elected a Foreign Associate of the US National Academy of Sciences. In 1997 he became President of the Faraday Division of the Royal Society of Chemistry. At his first Faraday Discussion, he broke with tradition by replacing the President’s customary speech at the conference dinner by Hilary’s songs, with Alan at the piano! He was also heavily and successfully involved in the birth of the European journal Physical Chemistry Chemical Physics (known as PCCP) from a union of Faraday Transactions of the Royal Society of Chemistry and Berichte der Bunsen Gesellschaft für Physikalische Chemie. The journal has thrived and is now jointly owned by 14 European chemical societies and published by the Royal Society of Chemistry.

In 1999 Alan was appointed a Commander of the Order of the British Empire and in 2000 he was elected to an Honorary Fellowship at Downing College, Cambridge.

To mark Alan’s 65th birthday and his impending retirement, his friends and colleagues in Southampton and Oxford organized a conference and social event in January 1999 in St John’s College, Oxford. It was attended by more than 100 people from many parts of the world. Alan gave the first lecture, and his family and friends contributed much beautiful music.

**Retirement**

Alan retired from his Royal Society Research Professorship and from his chair at the University of Southampton at the age of 65 years on 30 September 2000. He and his colleague John Brown were writing a book entitled Rotational spectroscopy of diatomic molecules (25). The writing was well underway before retirement and continued from his home in Chandler’s Ford, aided by the award of a Leverhulme Senior Fellowship, which provided the means to attend conferences overseas. The book took five years to write and was published by Cambridge University Press in 2003. It has 1013 pages and 11 chapters that develop the theory behind the energy levels of diatomic molecules and summarize the many experimental methods of studying the high-resolution spectra of these molecules in the gaseous state.

Alan’s retirement was enriched especially by music, but also by a love of the English countryside and of boats, including the building of intricate models of classic sailing ships, including Victory and Cutty Sark. Alan and Hilary would often visit Beaulieu, where Victory was built. He was a heavy smoker for much of his life but succeeded in giving up the habit in 2000. His health remained good until 2011 when he was treated for pancreatic cancer. He died in Winchester Hospital, surrounded by his family.
Biographical Memoirs

ACKNOWLEDGEMENTS

We have drawn heavily upon Alan’s article in *Annual Review of Physical Chemistry* (24) and from his unpublished autobiography. We are grateful to Hilary Carrington, Professor Brian Howard and Dr Andrew McLachlan for many helpful comments, and to Mrs J. Cardnell, Head of Careers & Librarian, Colfe’s School, for information about Alan at school and for providing the photograph in figure 1.

The frontispiece photograph was taken in 1977 by Godfrey Argent and is reproduced with permission.

BIBLIOGRAPHY

The following publications are those referred to directly in the text. A full bibliography is available as electronic supplementary material at http://dx.doi.org/10.1098/rsbm.2015.0024 or via http://rsbm.royalsocietypublishing.org.


Alan Carrington


