obituary

R. G. W. Norrish, 1897-1978

THE death of Professor Ronald George Wreyford Norrish in his 81st year at Cambridge on 7 June 1978 marks the passing of an era notable for remarkable developments in chemistry, among which must be included the advance to maturity of reaction kinetics as a discipline in physical chemistry. Throughout Norrish's research career, extending over more than forty years, he was intimately concerned with a wide variety of subjects, including photochemistry, atomic and free-radical reactions, chain processes such as ignition and combustion and polymerisation, and energy transfer between and within molecules. In all these his studies led to important, and sometimes revolutionary, advances. Wide as his research activities were, yet they were intertwined, with the thread of an intense interest in the behaviour of activated species and the study of the latter by kinetic techniques, running through them.

Norrish's first photochemical work, carried out in 1923 in collaboration with E. K. Rideal, was a study of the photochemistry of aqueous potassium permanganate solutions. At that time photochemistry was in its infancy. The first application of quantum theory to photochemistry had been made by Einstein in 1912 in the form of his law of photochemical equivalence (although in some respects this was anticipated by work of Stark) and its precise applicability to photochemical reactions was still a matter for debate. The remarkable paper by Franck on the elementary processes of photochemical reactions did not appear until 1925. Norrish published a number of interesting papers before 1930, notably those on the photochemistry of nitrogen dioxide, in which he demonstrated a photochemical threshold and the achievement of a photostationary state.

In the period up to the middle 1930s correlation between photodecomposition and photophysical phenomena, such as spectral character and the appearance of fluorescence, engaged the attention of photochemists and Norrish's laboratory in Cambridge occupied a prominent position in these studies. Of his photochemical work before World War II, his long series of investigations of the photolysis of carbonyl compounds is perhaps particularly far-reaching.

The first paper, in 1928, concerned with the photodecomposition of glyoxal, was followed by reports of studies of formaldehyde, acetaldehyde, acetone and a variety of aldehydes and ketones carrying longer hydrocarbon chains. These led to the recognition of the now famous Norrish Type I and Norrish Type II reactions, illustrated by the equations

$$R^1COR^2 + h\nu \rightarrow \dot{R}^1 + \dot{C}OR^2 \rightarrow \dot{R}^1 + \dot{R}^2 + CO \qquad (I)$$

$$R^1COCH_2CH_2CH_2R^2 + h\nu \rightarrow R^1COCH_3 + CH_2:CHR^2 \qquad (II)$$

in which the groups R^1 and R^2 are understood to contain one or two carbon atoms. The observation that Types I and II reactions are influenced strongly by the physical environment—i.e. whether gas phase or condensed phase—provided a most important 'spin-off', namely the first experimental illustration of the Franck-Rabinowitch cage mechanism operative in solution.

Norrish's interest in intense light sources for photolysis seems to have arisen during World War II. I recall a comment (suitably embellished), made near the end of the war, that he intended to get a searchlight to photolyse keten and to trap the resulting methylene by the Paneth method. At that time, rudimentary ideas of flash photolysis may have been growing in his mind.

Flash photolysis, pioneered by Norrish and Porter and their coworkers, was a truly revolutionary development. It makes use of a powerful short-lived 'photoflash' which brings about rapid dissociation of the absorbing species into radicals or atoms. A second weaker spectroscopic flash ('specflash') triggered electronically at a precise interval after the first, permits the observation of transient species and by varying the time between the two flashes the kinetics of the formation and decay of such species may be studied. A fascinating account of these developments, extending from pyrolysis and combustion processes to vibrational relaxation phenomena, was given by Norrish in his Faraday Lecture to the Chemical Society. The immense impact of this technique on the study of fast reactions and the behaviour of active species is now too well-known to require description and the award of the

Nobel Prize for Chemistry in 1967 jointly to Norrish and Porter and to Eigen was universally welcomed.

Norrish's interest in chain processes was evident from his early work on the hydrogen-chlorine reaction in which he elucidated the inhibitory effects of oxygen and ammonia. Adoption of a new technique (continuous photometric analysis) enabled Norrish and Ritchie to establish that the retarding effect of HCl in pure systems and systems containing oxygen is attributable to the process

$$\dot{H} + HCl \rightarrow H_2 + \dot{C}l$$

Norrish's work on the kinetics of this chain reaction, many features of which had defied solution by earlier workers, established his eminent position among kineticists.

Much of Norrish's work on combustion was centred on the transition between slow reaction and ignition and particularly the dependence of the ignition boundaries on the concentrations of various additives (e.g. NO_2, NOCl, CCl_3NO_2). During the early stages, Semenov was developing his classical theories of thermal and isothermal ignition; Norrish saw the necessity for combining both these in a branched-chain thermal theory. Although some of the detailed interpretations have been modified as the result of applications of new experimental techniques, there is no doubt that the beautiful work of Norrish and his colleagues, made over a long period, has provided much of the basis of our present understanding of these complex processes. The experimental demonstration of degenerate (or delayed) branching in hydrocarbon combustion was an outstanding contribution.

In the field of polymerisation, Norrish also made pioneering kinetic studies. The best-known is probably that concerned with the acceleration which occurs in the later stages of free-radical polymerisation, to which the name 'gel-effect' has now been attached. Norrish and Smith showed that this is the result of a steadily decreasing rate of chain termination which sets in when the viscosity becomes high. A nice example of the cross-fertilisation of his ideas is provided by his work on the photolysis of poly(methylvinylketone), which was found to undergo photolysis in solution according to both Types I and II. The former yields macroradicals which, in the presence of a polymerisable monomer, give block copolymers.

Norrish had intense energy and enthusiasm and an all-consuming desire to get to the bottom of things by experimental means. These qualities could be disconcerting to his research students, who were sometimes expected to obtain definitive results between 9.30 a.m. and 6.0 p.m. on the same day (bank-holidays included!). Norrish was a generous and warm-hearted, yet forthright, person. His membership of the Savage Club reflected his enjoyment of meeting people, especially those distinguished in professions remote from his own. He had a tremendous zest for life and his hospitality became legendary, not only on the more formal occasions, but also in his entertainment of friends and colleagues from all parts of the world at his home in Park Terrace. There, one might be regaled with recordings of Japanese music or a lecture by Rutherford, or enter into quasi-philosophical discussions of the 'fourth law' of thermodynamics and when Norrish received his honorary degree in the University of Liverpool, the Public Orator recalled the remarkable aptness of Praed's words

'Beginning with the laws which keep
The planets in their radiant courses,
And ending with some precept deep
For dressing eels, or shoeing horses.'

It might truly be said that with Norrish every evening was Christmas eve.

Things Cantabrigian occupied a very special place in Norrish's affections. He was born and educated in Cambridge and effectively spent all his working life there. In 1937, after the death of T. M. Lowry, he had become the second holder of the Chair of Physical Chemistry and subsequently the head of the separate Department of Physical Chemistry. He was justifiably proud of the department he had built up and had strong associations with his College (Emmanuel) of which he was Senior Fellow at the time of his death. His lectures on physical chemistry were often vividly illustrated by spectacular demonstrations of his favourite phenomena in photochemistry and chain processes. During the war, his department was largely concerned with problems related to the war-effort, such as suppression of gun flash and the development of incendiary materials; during this time Norrish was Chairman of the Incendiary Projectiles Committee.

Norrish's distinction naturally led to his receiving many honours. He was elected Fellow of the Royal Society in 1937 and received honorary doctorates from the Sorbonne, and the Universities of Lancaster, Leeds, Liverpool, Sheffield and British Columbia. He was awarded the Meldola Medal of the Institute of Chemistry (1928), the Davy Medal of the Royal Society and the Liversidge Medal of the Chemical Society (1958), the Lewis Gold Medal of the Combustion Institute (1964), the Faraday and Longstaff Medals of the Chemical Society (1964, 1968) and was a member of eight foreign Academies of Science. During 1953–55 he was President of the Faraday Society, and in 1961 was President of Section B of the British Association for the Advancement of Science. In 1966 he gave the Bakerian Lecture of the Royal Society. Nothwithstanding all his honours, he retained an innate modesty which allowed him to accord to others, particularly his junior colleagues, due appreciation of their efforts.

In 1926 he married Anne, the eldest daughter of A. E. Smith, of Manchester, who survives him. They had twin daughters.

C. H. Bamford

J. P. Kendall

Professor James Pickering Kendall, F.R.S., F.R.S.E., Emeritus Professor of Chemistry, University of Edinburgh, died in Edinburgh on 14 June 1978.

He was born on 30 July 1889 in Chobham, Surrey, and was educated at Farnham Grammar School and Edinburgh University. A distinguished undergraduate career was followed by work on exact conductivity measurements, first in Edinburgh and later with Svante Arrhenius at the Nobel Institute, Stockholm. Kendall was inspired by Arrhenius, but found research facilities in the Institute disappointing and after a spell he went to the better equipped Technological Institute of St. Petersburg.

In 1913 Kendall went to Columbia University, New York, as an instructor in chemistry and in 1922 was promoted to a full professorship. He carried out research on a variety of topics including the formation of addition compounds in solution and ionisation equilibria. A good example of his incisive and discriminating approach to research is contained in a long, critical and polemical paper on the properties of strong electrolytes in solution in which facts and arguments are marshalled against the views and postulates of Ghosh.

Probably his most important work was the attempt to separate isotopes and mixtures of rare earths, a pioneer effort at a period when the sophisticated armoury of the modern chemist was not available. Isotopic separation eluded him, but by the ionic migration method he effected a substantially complete separation of yttrium from erbium. At the same time he undertook the revision of Alexander Smith's famous series of chemistry textbooks, a task which made increasing demands on his time and energy.

In 1927 Kendall was elected a Fellow of the Royal Society and a year later succeeded Sir James Walker as Professor of Chemistry in the University of Edinburgh, a post he held until his retirement in 1958. He immediately made full use of his administrative ability and business acumen into extending the research facilities of his department, and with the help of men like J. A. V. Butler, E. B. Ludlam, M. Ritchie and H. W. Melville, succeeded in building up a thriving school of physical chemistry. Apart from unsuccessful attempts to separate the hydrogen isotopes in water and to detect the calcium isotope with mass 41 in the potassium-rich deposits of Rhiconich in Sutherlandshire Kendall gave up research and concentrated on writing books. These included *At Home among the Atoms* and *Young Chemists and Great Discoveries* and the lively and readable biographies of Michael Faraday and Humphry Davy. In 1938 he wrote *Breathe Freely* in which he correctly predicted that in the event of war poison gas would not be used.

Kendall was an excellent lecturer and he gave the 1938/39 course of Christmas lectures at the Royal Institution, in London. In one of the lectures he performed the famous boiling lead experiment, when his daughter Jean passed her hand through the stream of white hot metal. He also took a great interest in the Royal Society of Edinburgh and served first as General Secretary (1936-1946) and then as President (1949-1954). In his younger days he enjoyed bicycling and he was a very good bridge player. He was twice married and his second wife, Jean, tended him devotedly in his latter years of ill-health. He leaves a son and two daughters.

Neil Campbell