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John Robert Anderson 1928–2007

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John Anderson was born in Sydney on 5 March 1928 and died in Melbourne on 26 February 2007. He was educated at Sydney Boys' High School, Sydney Technical College, the New South Wales University of Technology (now the University of New South Wales) and the University of Cambridge. He was at Queens University Belfast as a Ramsay Memorial Fellow, 1954–5, was a Lecturer in Chemistry at the New South Wales University of Technology, a Reader in Chemistry at the University of Melbourne and Foundation Professor of Chemistry at Flinders University in South Australia. In 1969 he was appointed Chief of the CSIRO Division of Tribophysics and managed the Division's transition to become the Division of Materials Science. He was a Professor of Chemistry at Monash University, Melbourne, from 1987 until his retirement in 1993. He will be remembered for his contributions to the understanding of gas–solid interactions with particular emphasis on fundamental heterogeneous catalysis on metals, but also embracing other adsorption and oxidation processes.

Family Background

John Robert Anderson was born in Sydney on 5 March 1928 and died in Melbourne on 26 February 2007. He was the only child of John Anderson, an electrical fitter, and Annie Caroline née Billington, a saleswoman. John's father died in August 1940 during John's first year at secondary school. The family lived in a flat in Liverpool Street, Darlinghurst, and after his father's death his mother returned to work to support them.

John married Betty Martha Spinley (known as Martha) in Sydney on 3 March 1956. Martha was the daughter of Charles William Spinley, a master butcher, and Emma Margaret née Jordan. John and Martha had two sons, Matthew John Anderson (1959) and Charles Nicholas Anderson (1961). They were divorced in 1978 and John never remarried.

Secondary Education

John gained admission to Sydney Boys' High School, a competitive-entry state public school, in 1940. There he met Arthur Pulford, a fellow student, who has kindly provided information regarding John's early life. John's results in the 1944 Leaving Certificate Examination would not have led anyone to predict the distinction of his later career. At that time he obtained B class passes in English, French, and Mathematics II; A class passes in Mathematics I and Physics;

and Second Class Honours in Chemistry (*The Record*, 1944).

Early Employment and Tertiary Education

When John left school it was not financially possible for him to go to university, so he took a job as a research assistant at the Australian Wool Realization Commission Testing House in Randle Street, Sydney. The Australian Wool Realization Commission was the Australian subsidiary of the United Kingdom-Dominion Wool Disposals Ltd, an organization established after the Second World War to buy, hold and sell wool on behalf of the UK, Australia, New Zealand and South Africa. At that time wool promotion and research was the responsibility of the Australian Wool Board and research was largely conducted by the Council for Scientific and Industrial Research in temporary facilities in Randle Street. The situation of the laboratory was excellent, for it allowed John to study for a Diploma in Chemistry in the evenings at the nearby Sydney Technical College. He commenced his studies in 1945. Even before doing so, he had a publication in *Nature*, 'Twist in Wool' (1), based on his work at the laboratory.

While John was still studying for his diploma, the Sydney Technical College became the New South Wales University of Technology and A. E. Alexander arrived as Professor of Chemistry. This was highly fortunate for John in that Alexander took him under his wing and persuaded him to convert from a diploma to a degree course. He graduated with First Class Honours in Chemistry in 1950. In 1952 Alexander encouraged him to apply for the newly created postgraduate scholarship established by the Australian subsidiary of the Royal Dutch Shell company, to go the University of Cambridge. John was a strong candidate for he already had two publications in preparation or in press in addition to the earlier paper in *Nature*. One was with Alexander, 'The surface tension and surface potential of aqueous solutions of aliphatic alcohols' (3) and the other with S. E. Livingston, 'Halostannates (IV) of some complex cations' (2). Livingston went on to become a very distinguished inorganic chemist. In an Australia-wide competition, John was one of the two inaugural winners of the Shell Scholarship.

University of Cambridge and Queens University Belfast

The award of the Shell Scholarship allowed John to study for a PhD at Cambridge. His supervisor there was Charles Kemball who was establishing himself as an expert in the field of heterogeneous catalysis. John enthusiastically participated in this work and gained enormous expertise in the catalysis of reactions of organic compounds on metal films. At Cambridge, Kemball used a continuous bleed of the gas phase into a mass spectrometer in a seminal study of the exchange of deuterium into methane over a good selection of transition-metal film catalysts. From the extent of deuteration, this work gave a good insight into the efficacy of dissociative adsorption and accordingly carbon-metal bonding on the various metal catalysts. When John arrived in Cambridge, he was given the task of extending this approach to the higher alkanes and in particular, ethane. While the same general principles for dissociative adsorption were evident, dissociative ethane adsorption was envisaged as occurring in a manner whereby bonding to the surface flipped between the two carbon atoms during a molecule's sojourn on the surface.

Kemball was appointed to the Chair of Chemistry in the Queen's University at Belfast in 1955 and John went with him, spending some time working at Queen's to complete his PhD after being awarded a highly competitive Ramsay Memorial Fellowship. Overall this fruitful collaboration led to papers in *Proceedings of the Royal Society* (4, 5), *Transactions of the Faraday Society* (6) and *Advances in Catalysis* (7, 10).

New South Wales University of Technology

A letter from the Bursar of the University of New South Wales to CSIRO dated 10 July 1970 indicates that John had continuous service at the University from 7 March 1949 until his resignation on 1 February 1957. Until September 1954 he was regarded as employed in some capacity, though presumably for most of the time unpaid, while studying in Sydney and Cambridge. He was appointed a Lecturer in Chemistry in September 1954, but was immediately granted leave without pay to take up his Ramsay Memorial Fellowship in Belfast. He returned to the New South Wales University of Technology

in 1955 to take up his Lectureship. (The University became the University of New South Wales in 1958.)

University of Melbourne

John was appointed a Senior Lecturer in the Department of Chemistry at the University of Melbourne commencing on 4 February 1957 and earned rapid promotion to Reader.

The University of Melbourne already had a strong solid state-surface chemistry group under the leadership of Professor J. S. Anderson—no relative of John's but probably the reason John was commonly known as 'JRA'. John immediately recommenced his research, publishing a review on catalytic exchange between deuterium and saturated hydrides (8), a single-author paper on the hydrogenation of benzene and toluene over evaporated films of nickel and tungsten (9), and a practical description of a pressure gauge (11). This last paper is written affirmation of John's skill as a hands-on experimental scientist. He soon built up a research group with PhD students who themselves went on to distinguished careers in chemistry, including Bruce Baker, Neville Clark and Neil Avery.

Bruce Baker set about extending the general approach that John and Kemball had exploited in the UK, studying the hydrogenolysis of the higher alkanes over metal-film catalysts similar to those used by Kemball. At temperatures higher than those needed for deuterium exchange, ethane, propane and the isomeric butanes were shown to hydrocrack to lower alkanes. This work also demonstrated an unexpected facile isomerisation of the butanes over platinum and, to a much less extent, palladium. For this work, Bruce used gas chromatography to separate the alkane products, which were then detected with a (thermal conductivity) cathetometer detector. Prior to this, the only known involvement of platinum in catalytic alkane isomerisation was as the hydrogenation-dehydrogenation component of the Houdry bi-functional acid catalyst developed in the 1930s, a technology that had become very important to the allies during the Second World War for the production of high-octane petrol.

During this time, John embarked on a major project to build a mass spectrometer. The task was prodigious but fortunately he had established, with a series of tutorials, a strong rapport with the ICIANZ Research Laboratories at Deer Park, and was able to garner a grant from the company to buy an AEI MS10 mass spectrometer instead. With the MS10 commissioned, Neville Clarke set about studying the exchange of deuterium with amines over the familiar suite of metal-film catalysts. When Neil Avery joined John's group in 1962, he was assigned the task of probing the mechanism of the butane isomerisation reaction over platinum, discovered in Bruce Baker's time.

As a result of John's association with ICIANZ, he would have been aware of their newly invented (McWilliam and Dewar 1958) flame ionization detector. John soon assembled one in an inverted toffee tin and, with a new Keithley 610 MOSFET electrometer (costing the equivalent of the then current-model Holden car) and replacing Bruce's adsorption gas chromatography column with a partition column, the analytical capability of the rig was much improved. In those days of improvization, these columns were packed by hanging 1/4-inch-diameter copper tubing down the stair well of the Chemistry Department—its mere four floors limiting the maximum length of the column. Initial kinetic work was extended to the pentanes where the observed facile isomerisation of neopentane immediately excluded the possibility of a π-bonded reaction intermediate.

Significant progress came with two entirely new experimental approaches, unprecedented in catalytic research of this kind. In 1964, n-butane-1-^{13}C was synthesized and reacted over standard platinum-film catalysts that had been shown, by John Sanders at the adjacent CSIRO Division of Tribophysics, to expose randomly orientated surfaces. To facilitate these experiments, a gas chromatography mass spectrometer was developed as a serious research tool. This was probably the first such unit to be made and deployed in Australia, although it was not then referred to as a GCMS.

Operationally, it involved collecting the separated alkanes from the gas chromatograph column in u-traps chilled by liquid air for transfer to the MS10. Of prime interest was the fate of the ^{13}C during the isomerisation reaction; this could be determined by a quantitative analysis of the propyl ion fragments produced during ionization within the MS10. The first results indicated

that the isomerisation product was mainly the improbable iso-butane-2-^{13}C. The problem was eventually traced to carbon dioxide contamination during collection of the separated fractions. Once this was removed, the ^{13}C in the iso-butane was shown to reside exclusively in the terminal methyl groups. Interestingly, it was also shown that in a fraction of the n-butane-1-^{13}C, the ^{13}C had move to the 2 position.

A reaction mechanism based on a 1,3 di-adsorbed (bridge-bonded) intermediate was able to quantitatively predict the ratio of iso-butane-1-^{13}C to n-butane-2-^{13}C seen experimentally. Geometrically, the C1-C3 distance in the proposed intermediate matched very closely the Pt-Pt distance on the catalyst surface, indicative of very low strain in this bonding configuration.

By this time, Bruce Baker had moved to the CSIRO Division of Tribophysics where part of his work involved growing metal films epitaxially on cleaved mica and evaporated sodium chloride substrates. The resulting films exhibited preferred (111) and (001) surface orientations, respectively.

Platinum films prepared in these ways were then used for reactions with both the isomeric butanes, where it was shown that only iso-butane over the (111)-orientated films resulted in a considerable enhancement of the isomerisation to n-butane.

This was entirely consistent with the previously established bridge-bonded intermediate in that the iso-butane molecule could now tri-adsorb in a relatively strain-free manner on the close-packed trigonal array of platinum atoms presented at the (111) surface.

Probably for the first time, the reactive intermediate and its modus operandi in a heterogeneous catalytic reaction had been established with a satisfying degree of certainty. This reaction became known as the 'Anderson and Avery' reaction and garnered widespread international interest. This interest extended beyond the identification of a credible mechanistic intermediate to the tantalizing prospect that catalytic pathways could be tuned by judiciously manipulating the geometric structure of the catalyst surface. To this end, the generic term 'demanding reactions' was coined. John was later to commit much of his research to this end, particularly in collaboration with Dr Karl Foger.

John Anderson's postgraduate students at the University of Melbourne have themselves made significant contributions to Australian science. Bruce Baker spent a few years in the CSIRO Division of Tribophysics before being appointed by John in 1966 to the academic staff of the Physical Sciences Department at the new Flinders University of South Australia. In 1984 he was promoted to Professor of Physical Chemistry. His research interests remained close to surface science until his retirement in 1997.

Neville Clark became a post-doctoral fellow with J. S. Anderson at Oxford until appointed by John in 1967 to the academic staff at Flinders University. His research interests moved to the chemistry of troposphere pollution. In 2002 he retired as Professor from the School of Chemistry, Physics and Earth Sciences.

Neil Avery held post-doctoral fellowships at the new University of East Anglia (with Professor Norman Sheppard FRS) and the University of Chicago (with Professor Robert Gomer) before returning to Melbourne in 1968 as a Research Scientist at the CSIRO Division of Tribophysics. His research interests remained largely in the realm of the physics and chemistry of surfaces although he was later to move more to materials science and energy-related electrochemistry.

Bruce McConkey worked with John on alkyl halide reactions on metal films. He was later to develop a professional career in industrial polymers with Fibremakers (in both Australia and the UK) and Nylex. After leaving Nylex he established his own business in manufacturing and distributing a range of polymeric products, culminating in boat-building epoxies that necessitated a move to Brisbane.

With John, Andrew Swanson studied the non-stoichiometry and catalytic activity of cuprous and plumbous oxides. He went on to complete a DPhil at Oxford with J. S. Anderson. After a brief stint with Nalco in Chicago he returned to Australia to work with ICIANZ, largely in senior managerial positions at Osborne, South Australia, and Botany, New South Wales. He later moved to New York as Vice-President and Director Chemicals with Nextant Inc.

Ian Ritchie commenced his PhD part-time in 1962. In 1972 he moved to the University of Western Australia as Associate Professor of Physical and Inorganic Chemistry and in

1984 was appointed Professor of Chemistry at Murdoch University. He retired in 2002.

Flinders University

In 1965 John was appointed to a Chair of Physical Sciences at the newly created Flinders University of South Australia, Adelaide's second university. He threw himself into the demanding task of setting up an exciting new School of Physical Sciences that integrated the disciplines of physics and chemistry, and took on the chairmanship of the School from 1967 to 1969. John together with Professor Max Brennan built up superb workshops to support John's catalysis work and Brennan's plasma research, which Neville Clarke believes were the best in any Australian university at the time. With this facility John soon re-established his research group, benefiting from strong financial support from the Australian Research Grants Committee (later the Australian Research Council) and further technical support from the university. He thus continued to produce high quality work in surface chemistry and catalysis that resulted in a series of papers (25–34, 37–41). In addition, he maintained his interest in practical techniques, publishing a paper on a new injection device for gas chromatographic samples in micron pressure range (33). In addition to his research and his helping to build up a new university, John contributed to the general promotion of science and was the inaugural Chair of the Royal Australian Chemical Institute's Solid State Division, overseeing its first meeting, in Adelaide, in 1968.

Career at CSIRO

In September 1967 John was asked to give his views on the future activities of CSIRO's Division of Tribophysics following the retirement of the then Chief, Dr Walter Boas. He wrote a three-page letter outlining his opinion. He noted that the Division was doing work in:

(a) Properties and behaviour of defects in metals
(b) Studies of metal surfaces including adsorption and catalysis, and
(c) Preparation and properties of thin metallic films.

He suggested that the Division should stay in these areas but expand its work in (b) and (c). He noted that these two areas span chemistry and physics and are difficult to do in a university. He also suggested that developments in Transmission Electron Microscopy should help research in catalytic chemistry. 'My general conclusion', he wrote, 'is that a research group in catalysis and surface science should have a two pronged program directed towards fundamental and towards applied objectives. The applied work should be carefully thought out and not merely embarked upon on an *ad hoc* basis.'

The position of Chief of the Division of Tribophysics was advertised on 13 December 1968. Walter Boas retired on 9 February 1969 but a successor had yet to be appointed when John Anderson put in a late application dated 21 July 1969. He was subsequently offered the position and accepted it on 18 September 1969. There is some curious correspondence relating to this appointment on the CSIRO file. John was invited to a discussion with the CSIRO Chairman, Dr J. R. Price, in early September and mistook the outcome of this to be an offer of appointment. His acceptance letter dated 18 September said that he was willing to come but wanted to be appointed as a Chief Grade 3, not the Chief Grade 2 that was mentioned by Dr Price. Dr Price wrote back to him saying that he had accepted a position before it had been offered to him and that it was unlikely that it would be offered at Chief Grade 3. It was eventually offered at that level, however, and John commenced on 21 May 1970. He remained at that level for his whole term as Chief.

The Division of Tribophysics started as the CSIR Lubricants and Bearings Section, established in 1939 as a wartime laboratory to do research related to the manufacture and maintenance of aircraft bearings, the nature of the initiation and propagation of explosive reactions, the measurement of the muzzle velocity of projectiles, and improvements in oils and lubricants. It was renamed the Tribophysics Section in 1946 and afforded Divisional status in 1948. The post-war research programme of the Division concentrated on two main areas: the behaviour of solids under stress and the relation between structure and properties of crystalline surfaces, particularly the performance of such surfaces as catalysts.

The Division that John joined in 1970 was quite small even by the standards of those days. It had a scientific staff of 27 and a total staff of 54. This increased considerably in the second half of

1970 when the Organisation decided to transfer some of its mineral research activities to Western Australia. The first Division to be transferred was the Division of Applied Mineralogy, then located at Fishermens Bend in Melbourne, but not all of the Division was transferred: the small polymer group led by Dr D. H. Solomon went to the Division of Applied Chemistry, and the Engineering Ceramics and Refractories Group went to the Division of Tribophysics. At the same time the Organisation's small Physical Metallurgy Section, located at the University of Melbourne, was also transferred into the Division of Tribophysics (Schedvin and Trace 1978).

The 1970s was a time of great change for CSIRO. The Birch Report (Birch 1977) recommended that its principal type of research should be 'strategic mission oriented' and that its research users should be more involved in determining the research programmes. It also recommended that Divisions be grouped into Institutes. The Division of Tribophysics became part of the Institute of Physical Sciences. In addition to these changes the staff and facilities of the Materials Research Laboratories of the Department of Defence in Adelaide were transferred to the Division. To reflect these changes the name of the Division was changed from 'Tribophysics' to 'Materials Science'. By 1978 the Division had expanded to a total of 142 staff with 35 research scientists. There were four components:

- the Catalysis and Surface Science Laboratory, at Parkville,
- the Engineering Ceramics and Refractories Laboratory at Fishermens Bend,
- the Production Technology Laboratory, at Fitzroy, and
- the Production Technology Laboratory, at Woodville.

It is not clear what part John played in this expansion. It would appear that to some extent the changes were thrust upon him.

The large Division did not last long. In 1980 the Organisation decided to form a new Division of Manufacturing Technology from the more industrially orientated parts of the Division and John was retained as the Chief of the much smaller Division of Materials Science.

In 1985 the Government asked ASTEC (the Australian Science and Technology Council) to advise it on the future directions for CSIRO. The report released in November of 1985 (ASTEC 1985) recommended radical changes to the Organisation including establishing a Board with an independent Chairman. The Government accepted all the report's recommendations and in December 1986 appointed a former Premier of New South Wales, Mr Neville Wran, as the first Chairman of the Board. The ASTEC report recommended that 'CSIRO's main role be the conduct of applications oriented research combined with a commitment to ensuring the effective transfer of its research results to end users'. As part of this new direction the Organisation decided to merge John's Division of Materials Science with the former Division of Chemical Physics to form a new Division of Material Science and Technology. John was not appointed Chief of the new Division.

John was one of the last Chiefs appointed on an indefinite basis. This meant that the Organisation had to keep him either as a Chief or as a Chief Research Scientist until he was 65. His Division ceased to exist on 31 December 1986 but he would not turn 65 until March 1993. The Organisation arranged for him to resign as Chief on 31 December 1986 and to be reappointed as a Chief Research Scientist Grade 2 on 5 January 1987. He served out this appointment at the School of Chemistry at Monash University.

John was very active as a scientist while he was the Chief of the Division. He recruited several bright young chemists and enhanced his international reputation in catalysis by helping to establish the correlation between surface structure and reaction specificity. This involved extending his chemistry of catalysis on metal films (see for example 39, 45, 50, 60, 64) and contributing to an overview of the subject by being involved in several reviews (a, b, 43, 44). He also became interested in looking for new methods of preparing highly dispersed supported-metal catalysts, for example starting with metal cluster carbonyls (52) and bi-molecular metallic cluster compounds (49). His major research interest in his final years at the CSIRO laboratories was in catalytic chemistry involving zeolites (for examples 55, 62, 63, 66, 67, 69, 70, 74–76, 78, 81–83, 85) and intercalated materials (71, 91, 93). His authority in this field is demonstrated by his involvement in authoritative reviews, many with Professor M. Boudart (c–g and i–n) and a book,

Introduction to Characterisation and Testing of Catalysts, with K. C. Pratt (h).

Monash University

While at the School of Chemistry at Monash University, John shared an interest with Professor Roy Jackson in the ways in which homogeneous catalysts could be immobilized on or in solid supports, thus making them recoverable and reusable heterogeneous catalysts with greater commercial potential. The catalysts were designed to be used for reactions carried out in water, leading to increased potential commercial gain and reduced environmental impact. Attention focused on enantioselective homogeneous catalysts, which usually contain not only expensive metals but also expensive chiral ligands, making their recovery and reuse of even more commercial interest. It was also thought that constraining the catalyst within the pores of a mesoporous material might well lead to a restricted number of geometries in the transition states of these reactions, hopefully leading to higher enantioselectivity. The project was dependent on the availability of chiral catalysts and the expertise of Professor Ron Dickson was sought and a joint ARC grant obtained. The results obtained were as good as or better than those obtained by other groups, but the lack of reproducibility removed all chance of commercial exploitation although several papers were accepted for publication by international journals (90–96).

Professional and Post-retirement Activities

John was Chairman of the Royal Australian Chemical Institute's Solid State Division in 1967–8. He was elected a Fellow of the Australian Academy of Science in April 1972 and awarded a ScD degree by the University of Cambridge in April 1973. He gave the RACI Victorian Branch's Hartung Youth Lectures in 1971.

Outside chemistry, John's quiet but friendly personality led him to develop many friendships with people with whom he shared a range of interests. He loved music, being a regular concert-goer and opera buff. He was a keen bushwalker and in later years walked with the Jackson research group and his old friend Peter Fensham. He was 'un-Australian' in that he showed no interest in organized sport but his son Charles says that in his early years he was a keen chess player. As stated above, he was a practical man who enjoyed working with his hands and this extended beyond his enthusiasm for making scientific instruments. His home in the Melbourne suburb of Eltham was a testimony to this interest: he created gardens supported by sturdy retaining walls and a splendid self-constructed pagoda.

John maintained his interest in chemistry and his enthusiasm for research until the time came when he could no longer get in to Monash. He still asked how research was going when colleagues visited him in his nursing home.

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