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THE AUSTRALIAN NATIONAL UNIVERSITY
JOHN CURTIN SCHOOL OF MEDICAL RESEARCH
DEPARTMENT OF MEDICAL CHEMISTRY
ANNUAL REPORT 1965

STAFF

Professor:

A. Albert, B.Sc.(Syd.), Ph.D., D.Sc.(Lond.), F.R.A.C.I., F.A.A.

Reader:

D.J. Brown, M.Sc.(Syd.), Ph.D., D.Sc.(Lond.), F.R.A.C.I.

Professorial Fellow:

D.D. Perrin, M.Sc.(N.Z.), Ph.D., D.Sc.(Lond.), F.R.I.C., F.R.A.C.I.

Senior Fellow:

E. Spinner, M.Sc.Tech., Ph.D.(Manc.), F.R.A.C.I.

Microanalyst (Fellow):

Joyce E. Fildes, B.Sc.(Syd.), M.Sc., Ph.D.(Birm.).

Fellows:

W.L.F. Armarego, Ph.D.(Lond.), F.R.I.C.

G.B. Barlin, M.Sc.(Syd.), Ph.D.(A.N.U.), F.R.A.C.I.

Research Fellows:

N.W. Jacobsen, M.Sc.(W.Aust.), Ph.D.(A.N.U.).

V.S. Sharma, M.Sc., Ph.D.(Agra).

E. Kalatzis, B.Sc.(Alex.), Ph.D.(Lond.).

M.E.C. Biffin, Ph.D.(Lond.)(commenced September).

B.D. Batts, Ph.D.(Queensland)(commenced September).

T.J. Batterham, B.Sc., Ph.D.(N.S.W.)(commenced October).

Visiting Fellows:

G.B. Brown, Ph.D.(Cornell)(July 1st - Nov. 20th).

W. Pfeleiderer, Ph.D.(Stuttgart)(July 15th - Nov. 20th).

Visiting Research Fellow:

J.J. McCormack, Ph.D.(Yale) U.S. National Institutes of Health
Postdoctoral Fellow (until May 1966).

Head Technician:

J.S. Harper, A.R.A.C.I. (resigned September).

D.A. Maguire (commenced December).

STUDENT AND TEACHING ACTIVITIES

Mrs Janice M. Lyall, B.Sc.(Syd.), was awarded the degree of Doctor of Philosophy for her thesis 'A study of metathesis and fine structure in pyrimidine, pteridine, and related compounds.'

Mr T. Teitei, M.Sc.(Tokyo), was awarded the degree of Doctor of Philosophy for his thesis 'Aspects of tautomerism in the pyrimidine series.'

Mr I.H. Pitman, B.Sc.(Lond.)(commenced 26th November, 1962), has submitted for examination his thesis entitled 'A Kinetic Study of the Dimroth Rearrangement'.

The following are proceeding to the degree of Doctor of Philosophy: Mr R.V. Foster, M.Sc.(Lond.)(commenced 19th August, 1963; subject, 'Studies in Pyrimidines'); Mr J.G. Catterall, B.Sc.(Hull) (commenced 11th October, 1963; subject 'Investigation of Bi-heterocyclyls'); Mr I.G. Sayce, B.A., B.Sc.(Oxford)(commenced 4th November, 1963; subject 'Complex-formation between metals and sulphur-containing ligands'); Mr J. Smith, A.R.C.S.T.(Glasgow) (commenced 26th November, 1963; subject 'Studies in quinazolines and related compounds'); Mr M.N. Paddon-Row, B.Sc.(Lond.)(commenced 9th March, 1964; subject 'A study in pyrimidine and related heterocycles'); Mr J.W. Bunting, B.Sc.(N.S.W.)(commenced 17th February, 1964 as a Commonwealth Postgraduate Scholar; subject 'Rapid Reactions of Nitrogen Heterocycles in Water'); Mr P.W. Ford, B.Sc.(Monash)(commenced 15th February, 1965 as Masson Memorial Scholar, C.S.I.P.O.; subject 'A Study in substituted Pyrimidines'); Mr H. Yamamoto, M.Sc.(Tohoku)(commenced 12th April, 1965; subject 'Investigations of heterocycles with two or more ring-nitrogen atoms'; Mr Tzoong-Chyh Lee, M.Sc.(Tohoku)(commenced 18th October, 1965; subject 'A Study of Alkylated Pyrimidines and related heterocycles'); Mr W.V. Brown, B.Sc.(Durham)(commenced 19th October, 1965; subject 'Synthesis and kinetics of reaction of nitrogenous heterocyclic compounds'); Mr I.P.S. Kang, M.Sc.(Changidar)(commenced 21st October, 1965; subject 'Spectral studies of compounds containing carboxylate and related groupings').

Mr.W.W.Remeljei, B.Sc.(Adelaide)(commenced 3rd February, 1964) resigned July 1965; Mr.P.O.Watts, B.Sc.(Lond.)(commenced 30th August, 1965) transferred to Research School of Physical Sciences, December 1965.

Throughout the year, seminars were organized at fortnightly intervals by Dr.E.Spinner.

RESEARCH PROGRAMME

INTRODUCTION. The broad concerns of this Department are investigations of substances, of low molecular weight, which belong to chemical families in which powerful, but specific biological effects have been found. These aims are pursued by (i) organic chemical work involving synthesis, isomerization, degradation and analysis; (ii) physical chemical work involving electrochemistry, cryoscopy and osmometry, and spectroscopy of many kinds (ultraviolet, infrared, Raman, and nuclear magnetic resonance); (iii) inorganic co-ordination chemistry. The main lines of research being developed are (a) heterocyclic chemistry with special reference to vital cell constituents such as the nucleic acids (especially the chemistry of pyrimidines, purines, and pteridines; also analogues and inhibitors), and (b) quantitative studies of equilibria in mixtures of biologically-occurring heavy metal cations with biologically-occurring ligands (metal-binding substances) or simplified models of these.

Many molecules containing a fused pyrimidine ring have been shown, in this Department, to combine covalently with one molecule of water. Accordingly purines were investigated for evidence of this property. It was found that even examples having substituents that would specially favour hydration (as in 2-hydroxy-8-trifluoromethylpurine) gave rise to no detectable amount of hydration (Albert).

In recent years, there has been a renewal of interest in the biological uses of acridines, as mutagens, as vital stains, and as nucleic acid intercalators which selectively inhibit the synthesis of RNA and proteins. Accordingly, this Department has resumed the study of acridine chemistry. A new oxidative method has been found for converting 9-chloroacridines (and hence acridones) into acridines through the corresponding 9-hydrazinoacridines. Contradictions in the literature are resolved regarding the properties of 9-hydrazinoacridine. This oxidative method has also been examined in the quinoline and isoquinoline series with a view to finding the best reaction conditions, as well as the most likely reaction mechanism. In a new reaction, it was found that acridines, heated with sodium carbonate in boiling ethylene glycol, give the corresponding bi-acridanyls (Albert, Catterall).

Somewhat surprisingly, 7-hydroxypteridine, which has no tendency to add water or ethanol across a double-bond, nevertheless readily adds acetylacetone and various other types of Michael reagents. This reaction can be carried out in alkaline or neutral solutions, or at pH 2. Sodium hydrogen sulphite forms a similar 1:1 adduct. There are indications that many other pteridines behave in this way (Albert, McCormack).

Investigation of the polymers formed from 2-aminobenzaldehyde, on storage at room temperature, has shown that they are cage-like molecules and do not have the simple constitutions assigned to them in the literature (Albert, Yamamoto).

The following three paragraphs give recent results in a long term study of nucleophilic displacements in pyrimidines.

A quantitative study of the amination of methoxy- and methylthio- pyrimidines has been extended to the higher alkoxy- and alkylthio- homologues, which were found to be replaced only a little less rapidly. 2- and 4-Methylthiopyrimidine aminate at equal rates in contrast with the unequal amination rates for the corresponding methoxypyrimidines (D.J.Brown, Foster).

The first simple methylsulphonyl- and methylsulphinyl- pyrimidines have been prepared and their facile displacement reactions are being studied (D.J.Brown, Ford).

Chloropteridines have been shown to aminate more rapidly, but chloropurines less rapidly, than the corresponding pyrimidines (D.J.Brown, Lyall, England).

The Dimroth Rearrangement. According to the reaction conditions, 5-cyano-1,2-dihydro-2-imino-1-methylpyrimidine undergoes normal or abnormal rearrangement via an acyclic intermediate. The abnormal product, 4-amino-5-formyl-2,3-dihydro-2-imino-3-methylpyrimidine, undergoes a second abnormal rearrangement to 5-carbamoyl-2-methylaminopyrimidine (D.J.Brown, Paddon-Row).

1-Alkyl-2-alkylimino-1,2-dihydropyrimidines (with differing alkyl groups) undergo Dimroth rearrangement to an equilibrium mixture of two isomers whose ratio is a function of the nature of the alkyl groups. This ratio was conveniently determined by n.m.r. spectra (D.J.Brown, Harper, England).

Work on the kinetics and equilibria of the Dimroth rearrangement has been completed, and a mechanism which involves several equilibria has been proposed (Perrin, Pitman).

Equilibria involving metal complexes in aqueous solution have been further examined. Studies of the effect of hydrolysis in systems containing copper(II) and neutral ligands show that binuclear complexes are formed. Stability constants of ATP complexes of biologically important metal ions have been measured (Perrin, Sharma). A general computer programme has been developed

for calculating the stability constants obtained when a metal simultaneously forms several different kinds of complexes, including protonated and polynuclear species. An improved titration cell for precise potentiometric titration has been designed and built (Perrin, Sayce). The nature of the binding of tetracyclines to the mineral framework of bone has been explained (Perrin).

Preliminary studies of the addition of water to 8-azapurines and 2,4,8-tri-substituted pteridines have been made in the new rapid-reaction apparatus. The true pK_a values (anhydrous species) of several substances (e.g. quinazoline) which hydrate covalently have been measured similarly (Perrin, Bunting).

Vibration-spectroscopic studies of carboxylate ions have been extended into the aromatic series. It is found that the two CO_2 - stretching frequencies are affected differently by substituents in the aromatic nucleus (Spinner).

A comparison of the infrared spectra of some hydrated and some anhydrous hexachloroantimonates of 2-hydroxypyridines has revealed unexpected effects of interionic hydrogen-bonding on some aromatic skeletal stretching bands; the infrared spectra of the anhydrous hexachloroantimonates closely resemble those of 2-methoxy- and other 2-substituted pyridinium ions, whereas those of the hydrated salts, like those of 2-hydroxypyridine hydrochlorides, are rather different (Spinner).

A study of the effect of ring-deuteration on the vibration spectra of aminopyridines, aminopyridine cations, and pyridones, with a view to establishing details of bond structures and band assignments, is in progress (Batts, Spinner).

In extension of some previous work, the infrared spectra of concentrated solutions of methylformamide and dimethylformamide in aqueous acid have been determined. It has been shown that two acid-amide reaction products exist, and in hydrochloric acid (both HCl in H_2O and DCl in D_2O) the two products are in equilibrium with one another (Spinner).

A method has been worked out for the determination on sulphur in organic compounds on the sub-milligram scale required for specimens submitted by biologists. The procedure known as the "Hot-Flask Method" forms the basis for the new process (Fildes).

Investigation of a series of methylindolizines by nuclear magnetic resonance spectroscopy revealed that protonation can occur on two different carbon atoms although the positive charge always resides on the bridgehead nitrogen atom (Armarego).

The syntheses of four unsubstituted naphthyridines have been improved so as to permit the preparation of larger quantities and the investigation of their reduction. Both the cis- and trans- fused forms of decahydro-1,5-naphthyridine have been prepared and their structures assigned from physical data (Armarego).

A detailed study was made of the electronic effects of substituents (in the 2-position of some twenty quinazolines) on the covalent hydration that occurs across the 3,4-double bond. The results showed that although the first step in the covalent hydration is a nucleophilic attack by OH^- or H_2O on the 4-position, the addition (and retention) of a proton on N-3 (or N-1) constitutes another critical step in the reaction mechanism (Armarego, Smith).

The literature describes a product of unknown composition which arises from the condensation of o-aminoacetophenone and methazonic acid. With the aid of nuclear magnetic resonance and other physical methods, this is shown to be a constant melting mixture of o-aminoacetophenone (25%) and 1,2-dihydro-4-methyl-2-nitromethylquinazoline-3-oxide (75%)(Armarego, Batterham).

A long-standing problem in heterocyclic chemistry is how to measure the resultant of two opposing influences in 5-membered rings which contain two or more nitrogen atoms. These influences arise from the electron-withdrawing effects of a doubly-bound nitrogen atom, and the electron-releasing effect of a singly-bound nitrogen atom. A step towards the solution of this problem has been taken by measuring the kinetics of the reaction of bromo-N-methyl-tetrazoles and N-methyltriazoles with piperidine. Great differences

have been found in the reactivity of isomers that differ only in the position of the methyl-group, and hence in the position of the singly-bound ring nitrogen atom (Barlin).

New 2-, 6-, and 2,6-substituted 1,3,5-triazaindenes have been prepared. Methylation of 2-methylthio-1,3,5-triazaindene gave simultaneously three isomeric N-monomethyl derivatives. A study of ionization constants and ultraviolet spectra revealed that 1,3,5-triazaindenes have different sites of protonation depending on the nature and position of the substituents (Barlin).

The positions of hydration in several susceptible oxo- and imino-pteridines (most of them bearing an 8-alkyl-substituent) have been determined by gentle oxidation to pteridones. The surprising discovery was made that methyl-groups that are attached to the same carbon atom, as the (water-derived) hydroxy-group undergoing oxidation, are removed in the process (Jacobsen).

The mechanism of N-nitrosation of primary and secondary α - and γ -amino-N-heterocyclic bases has been studied. The work is being extended to include C-nitrosation and hydrolytic deamination (Kalatzis).

Nuclear magnetic resonance techniques show that cations of some tri- and tetra-azanaphthalenes (with nitrogen atoms in positions 1 and 4) add two molecules of water, across both C=N bonds of the pyrazine ring (Batterham).

Computer programs for calculation of theoretical n.m.r. spectra and for iterative matching of observed spectra have been adapted for use on the CDC 3600 computer at the CSIRO Computer Research Division (Batterham).

OTHER ACTIVITIES

Dr D.J.Brown delivered the H.G.Smith Memorial Lecture at Sydney University in February. Professor Albert contributed a paper to the Australian Academy of Science's Symposium on "New Perspectives in Insect Control" (April). Drs Perrin and Sharma read a paper in the Metal-Organic and Co-ordination Chemistry Conference at the University of New South Wales (May).

Spinner spoke in the Fifth Australian Spectroscopy Conference, Perth (June). At the Third Australian Symposium on Heterocyclic Chemistry, held in August at Monash University, the following members of this Department read papers: Professors Albert, G.B.Brown, and Pfeleiderer; Drs Armarego, Barlin, D.J.Brown, Jacobsen, and McCormack; Messrs Catterall, Foster, Paddon-Row, and Smith.

Dr D.J.Brown visited all the principal centres of pyrimidine research in the U.S.A., Europe, and Israel, during May-June, with the aid of a Smith Kline and French Grant.

Dr J.Fildes returned in September from 3 months study leave spent in Japan, Israel, Western Germany, Sweden, France, Great Britain, and the U.S.A. as part of a programme to examine the comparative performances of several commercially available automatic instruments for the simultaneous microdetermination of carbon, hydrogen, and nitrogen in organic materials. She also attended the Society of Analytical Chemistry's Conference at Nottingham University, and presented a research paper at the International Symposium on Microchemical Techniques at Pennsylvania State University.

Specimens of substances discovered in this Department have been sent, on request, to Dr S.P.Damle (Pharmacology Department, Tufts University Medical School, Boston); Dr.C.Scholtissek (Microbiology Department, University of Giessen, Germany); Prof.L.Goodman (Whitmore Chemical Laboratory, Pennsylvania State University); Dr H.Gordon (Smith Kline and French Laboratories, Philadelphia); Prof.H.Mautner (Yale University Medical School); and Dr D.Shugar (Institute of Hygiene, Warsaw).

Clinical trials of Dr D.J.Brown's new substance (2,4-diamino-7-hydroxymethylpteridine) as an anti-leukaemic agent are in progress (Dr M.Jacobson, Strandways Laboratories, Cambridge, and Dr L.K.Diamond, Children's Hospital, Boston, Mass.).

Absolute and S.V.R. ethanol were purified routinely for the whole John Curtin School. Several unavailable chemicals were synthesized for other Departments.

A Perkin-Elmer R10 nuclear magnetic resonance spectrometer (60 megacycles) has been installed and 1500 spectra determined for this and other Departments.

Spectroscopic service work in 1965 comprised the determination of 160 ultraviolet and 30 infrared spectra; 18 of the latter were for other Departments in the School. A Perkin-Elmer 621 dual grating infrared spectrophotometer was acquired in August 1965.

A total of 1763 requests for elemental analyses and special weighings were completed on the 758 samples submitted to the microanalytical section, supervised by Dr Fildes. This represents a 2% increase over that for 1964. About 90% of the analytical work was concerned with microdeterminations of carbon, hydrogen, and nitrogen. The data in the comparison tables indicates an 11% increase in the requests received from other Departments in this School. A more universally applicable packing has now been devised for the routine analysis service, particularly to cope with fluorine, mercury, antimony, and other metallic compounds submitted by the Biological Inorganic Chemistry Unit.

Mr B.T.England, a Senior Technical Officer in this Department, successfully completed his B.Sc. course at the School of General Studies.

PUBLICATIONS

ALBERT, A.

(Book) Selective Toxicity (third edition). Methuen and Co. London, xiii + 394.

'Acridine Syntheses and Reactions. Part VI. A New Dehalogenation of 9-Chloroacridine and its Derivatives. Further Acridine Ionisation Constants and Ultraviolet Spectra.'

Journal of the Chemical Society, 4653.

'Fundamental Aspects of Selective Toxicity.'

Evaluation and Mechanisms of Drug Toxicity.

Annals of The New York Academy of Sciences,,

123. Art.1, p.5.

ALBERT, A., ARMAREGO, W.L.F.

'Covalent Hydration in Nitrogen-Containing
Heteroaromatic Compounds. I. Qualitative Aspects.
Advances in Heterocyclic Chemistry, 4, 1.

ALBERT, A., CATTERALL, G.

'Acridine Syntheses and Reactions. Part VII.
Some Binuclear Acridines.'
Journal of the Chemical Society, 4657.

ALBERT, A., CLARK, J.*

'Pteridine Studies. Part XXVIII. Some 6- and
7-Substituted Pteridines.'
Journal of the Chemical Society, 27.

ALBERT, A., MCCORMACK, J.J.

'Pteridine Studies. Part XXX. Some Michael-Type
Addition Reactions of 7-Hydroxypteridine.'
Journal of the Chemical Society, 6930.

ARMAREGO, W.L.F.

'Triazaindenes (Giazaindolizines). The Site of Protonation.'
Journal of the Chemical Society, 2774.

ARMAREGO, W.L.F., GERSON, F.[†]

'E.S.R. Spectra des Radical-Anions des
1,4,5,8-Tetraazanaphthalens.'
Helvetica Chimica Acta, 48, 112.

ARMAREGO, W.L.F., SMITH, J.I.C.

'Quinazolines. Part VII. Steric Effects in 4-Alkylquinazolines.'
Journal of the Chemical Society, 5366.

ARMAREGO, W.L.F., WILLETTE, P.E.*

'Quinazolines. Part VI. 2,2'- and 4,4'-Biquinazolinyls.'
Journal of the Chemical Society, 1258.

BARLIN, G.B.

'Ionization Constants of Heterocyclic Substances.
Part VII. Cinnolines.'
Journal of the Chemical Society, 2250.

BARLIN, G.B., CHAPMAN, N.B.[†]

'Nucleophilic Displacement Reactions in Aromatic Systems.
Part IX. Kinetics of the Reactions of 2-, 6-, or
8-Chloro-9-methylpurine with Piperidine in Ethanol.'
Journal of the Chemical Society, 3017.

BROWN, D.J., ENGLAND, B.T.

'2,4-Diamino-7-hydroxymethylpteridine and Related Compounds.'
Journal of the Chemical Society, 1530.

BROWN, D.J., FOSTER, R.V.

'Pyrimidine Reactions. Part XII. The Thermal Rearrangement
of 2-Alkoxypyrimidines.'
Journal of the Chemical Society, 4911.

BROWN, D.J., HARPER, J.S.

'The Dimroth Rearrangement. Part IV. A Study of
Facilitation by Electron-withdrawal. Alkylated
2-Alkyliminopyrimidines.'
Journal of the Chemical Society, 5542.

BROWN, D.J., JACOBSEN, N.W.

'Pteridine Studies. Part XXIX. The Methylation
of 7-Amino- and 4,7-Diamino-pteridine.'
Journal of the Chemical Society, 1175.

'Pyrimidine Reactions. Part X. The Methylation of
Triaminopyrimidines: Conversion of the Resulting Imines
into Pteridines.'
Journal of the Chemical Society, 3770.

BROWN, D.J., LYALL, Janice M.

'Pyrimidine Reactions. IX. The Amination of Chloropyrimidines
with Branched Alkylamines and Di-n-alkylamines.'
Australian Journal of Chemistry, 18, 741.

'Pyrimidine Reactions. XI. Amination Rates for
Two Chlorodimethylpyrimidines without solvent.'
Australian Journal of Chemistry, 18, 1811.

BROWN, D.J., TEITEI, T.

'Pyrimidine Reactions. Part VII. Methylation of Substituted 2,4-Diaminopyrimidines.'

Journal of the Chemical Society, 755.

'Pyrimidine Reactions. Part VIII. Methiodides Formed From Some Dimethylaminopyrimidines.'

Australian Journal of Chemistry, 18, 199.

'Simple Pyrimidines. VIII. The Fine Structure of Isocytosine, Thlocytosine, and Some Isomers.'

Australian Journal of Chemistry, 18, 559.

BROWN, S.E., MAGUIRE, D.A., PERRIN, D.D.

'A Simple Mechanical Device for Improving N.M.R. Spectra of Dilute Solutions.'

Chemistry and Industry, 1974.

EVANS, R.F.* SHANNON, J.S.†

'Hydropyrimidines. Part IV. Catalytic Reduction of Substituted Pyrimidines.'

Journal of the Chemical Society, 1406.

PERRIN, D.D.

'Covalent Hydration in Nitrogen-Containing Heteroaromatic Compounds. II. Quantitative Aspects.'

Advances in Heterocyclic Chemistry, 4, 43.

'Multiple Equilibria in Assemblages of Metal Ions and Complexing Species: A Model for Biological Systems.'

Nature, 206, 170.

'Binding of Tetracyclines to Bone.'

Nature, 208, 787.

'Prediction of the Strengths of Some Organic Bases.'

Journal of the Chemical Society, 5590.

PERRIN, D.D., PITMAN, I.H.

'The Dimroth Rearrangement. III. Formation of 2-Hydroxypyrimidine from 1,2-Dihydro-2-imino-1-methylpyrimidine.'

Australian Journal of Chemistry, 18, 763.

'Rate Constants for a System, $A \rightleftharpoons B \longrightarrow C$, and an Application to the Dimroth Rearrangement.'

Australian Journal of Chemistry, 18, 471.

'The Dimroth Rearrangement. Part V. The Mechanism of the Rearrangement of 1-Alkyl-1,2-dihydro-2-imino-pyrimidines in Aqueous Solution.'

Journal of the Chemical Society, 7071.

SPINNER, E.

'Thermal Conductivity of an Equimolar H_2O - D_2O Mixture.'

The Journal of Chemical Physics, 42, 812.

WILLETTE, R.E.*

'Diazaindenes (Azaindoles) Part.III. Synthetic Approaches (Preliminary Results).

Journal of the Chemical Society, 5874.

* Based on work done while a member of this Department.

† Not a member of this University.

ACCEPTED FOR PUBLICATION

ALBERT, A.

(Book)

'The Acridines' (2nd edn.), pp.600.

London, Edward Arnold and Co.

'Purine Studies. Part IV. A Search for Covalent Hydration in 8-Substituted Purines.'

Journal of the Chemical Society.

ARMAREGO, W.L.F.

'C-1 and C-3 Protonation of Indolizines.'

Journal of the Chemical Society.

ARMAREGO, W.L.F., BARLIN, G.B., SPINNER, E.

'The Infra-red Spectra of some Diaza- and Triaza-naphthalenes and of 1,4,5,8-Tetraazanaphthalene.'

Spectrochimica Acta.

ARMAREGO, W.L.F., SMITH, J.I.C.

'Electronic Effects in 2-Substituted Quinazolines.'

Journal of the Chemical Society.

BARLIN, G.B.

'Ionization Constants of Heterocyclic Substances.

Part VIII. 1,3,5-Triazaindenes.'

Journal of the Chemical Society.

BARLIN, G.B., PERRIN, D.D.

'Prediction of the Strengths of Organic Acids.'

Quarterly Reviews.

BROWN, D.J., ENGLAND, B.T., LYALL, Janice M.

'The Formation, Ionization, and Spectra of Some Alkylamino-pteridines, -purines, and -pyrimidines.'

Journal of the Chemical Society.

BROWN, D.J., PADDON-ROW, M.N.

'The Dimroth Rearrangement. Part VI. The Abnormal Behaviour of 5-Cyano-1,2-dihydro-2-imino-1-methylpyrimidine.'

Journal of the Chemical Society.

BUNTING, J.W., PERRIN, D.D.

'Dianion Formation by 2- and 6-Hydroxypteridines.'

Australian Journal of Chemistry.

'Ionization Constants of Some Substituted Quinazolines
and Triazanaphthalenes.'

Journal of the Chemical Society.

FILDES, Joyce E., KIRSTEN, W.J.[‡]

'The Submilligram Determination of Sulfur in organic
compounds by the Hot-Flask Combustion Method.'

Microchemical Journal.

PERRIN, D.D., ARMAREGO, W.L.F., PERRIN, D.R.[‡]

(Book) 'Purification of Laboratory Chemicals.'

Pergamon Press.

PERRIN, D.D., SAYCE, I.G.

'A pH-Titration Cell for Precise Measurements.'

Chemistry and Industry.

PERRIN, D.D., SHARMA, V.S.

'Complex Formation by Hydrolysed Copper(II) Ions
in Aqueous Solution.'

Journal of Inorganic and Nuclear Chemistry.