150. *The Nuclear Magnetic Resonance Spectrum of* cis-1,2-*Difluoroethylene.*

By T. D. Coyle, S. L. Stafford, and F. G. A. Stone.

1,2-Difluoroethylene was obtained as one of the products of the reaction between diborane and tetrafluoroethylene [1] and by a more classical route.[2] In both cases the product was formulated as a "*cis–trans*"-mixture. We have now determined that both reactions yield predominantly (if not only) *cis*-isomer. The molecule is a simple example of an A_2X_2 nuclear-spin system, and analysis of the nuclear magnetic resonance spectrum reveals features which are of interest in the light of recent studies of other fluoro-olefins [3] and current interest in nuclear-spin coupling effects.

Vapour-phase chromatography, through several different columns, revealed only one component in a sample of 1,2-difluoroethylene from the diborane reaction. Isomeric purity was confirmed by ^{19}F and ^{1}H nuclear magnetic resonance measurements, which yielded identical ten-line spectra of the kind expected for a single A_2X_2 species. The general character of the infrared spectrum, especially the presence of a moderately intense band at 1730 cm.$^{-1}$ in the carbon–carbon double-bond stretching region, showed that the single isomer present is in fact the *cis*-compound. The infrared spectrum reported by Haszeldine and Steele [2] for what was also presumed to be a *cis–trans*-mixture agrees completely with the spectrum of our compound, indicating that their material is also the *cis*-isomer.

The relative stabilities of the two isomers are unknown. However, in the analogous 1,2-dichloroethylenes the *cis*-form is the more stable.[4] Appearance of only one isomer in the products of the diborane–tetrafluoroethylene reaction and of the dehalogenation may thus be due to thermodynamic factors and may not reflect any geometric specificity in the formation of the difluoroethylene.

The ^{19}F and ^{1}H nuclear magnetic resonance spectra are identical, consisting of ten lines disposed centrosymmetrically at 17·6, 18·9, 35·5, 38·2, and 46·0 c./sec. relative to the centre. The proton system is centered at $-6{\cdot}2_0$ p.p.m. (hexamethyldisiloxane internal reference) and the fluorine system at $167{\cdot}_7$ p.p.m. (trichlorofluoromethane external reference).

An analysis of the nuclear magnetic resonance spectrum for the general A_2X_2 case has been applied to 1,1-difluoroethylene.[5] It has been pointed out that the analysis does not yield the signs of the coupling constants, and that J_{HH} cannot be distinguished from J_{FF}, nor J_{HF} (*trans*) from J_{HF} (*gem*). However, reasonable assignments can be made by comparison with coupling constants in other molecules. The following assignments reproduce the observed line separations and yield calculated intensities in satisfactory agreement with the observed values: J_{HH} $2{\cdot}_0$ c./sec., J_{FF} $18{\cdot}_6$ c./sec., J_{HF} (*trans*) $20{\cdot}_1$ c./sec., J_{HF} (*gem*) $71{\cdot}_9$ c./sec.

The values of J_{HH} and J_{FF} are significantly lower than those found previously for similar molecules,[6] thus extending the range of "characteristic" spin coupling constants in fluoroethylenes. It is of interest that an unusually low coupling constant has also been reported between *cis*-protons for 1,2-dichloroethylene.[7]

Experimental.—cis-1,2-*Difluoroethylene.* The material used in this work was a sample from the original preparation of the compound in this laboratory,[1] repurified by fractional

[1] Bartocha, Graham, and Stone, *J. Inorg. Nuclear Chem.*, 1958, **6**, 119.
[2] Haszeldine and Steele, *J.*, 1957, 2800.
[3] McConnell, Reilly, and McLean, *J. Chem. Phys.*, 1956, **24**, 479.
[4] Wood and Stevenson, *J. Amer. Chem. Soc.*, 1941, **63**, 1650.
[5] McConnell, Reilly, and McLean, *J. Chem. Phys.*, 1955, **23**, 1152.
[6] See Pople, Schneider, and Bernstein, "High-Resolution Nuclear Magnetic Resonance," McGraw-Hill, New York, 1959, and references cited therein.
[7] Cohen, Sheppard, and Turner, *Proc. Chem. Soc.*, 1958, 118.

condensation in the vacuum-system. The infrared spectrum showed that the compound was not affected by prolonged storage in the vapour phase at room temperature.

Apparatus and instruments. A Perkin–Elmer vapour fractometer was used for the attempted separation into geometrical isomers. The instrument contained thermistor detectors, and used helium gas as carrier. Columns investigated were " di-isododecyl phthalate " on crushed firebrick (6 ft. and 12 ft. in length), activated charcoal (6 ft.), dimethylnaphthalene on crushed firebrick (6 ft.), and silver nitrate–glycerol on crushed firebrick (6 ft. and 12 ft.). Infrared spectra of the vapour were recorded with a Perkin–Elmer model 21 recording spectrometer equipped with a sodium chloride prism. Nuclear magnetic resonance spectra were measured with a Varian V4300B spectrometer equipped with superstabiliser. ^{19}F measurements were made at 40 Mc./sec., ^{1}H measurements at 40 and 60 Mc./sec. The samples, pure liquid with trichlorofluoromethane as an external reference and a 10% solution in carbon tetrachloride with hexamethyldisiloxane added (*ca.* 1%) as an internal reference, were contained in Pyrex sample tubes of 5 mm. outside diameter, sealed under a vacuum. A precision audio-oscillator and associated frequency counter were used for measurements of line separations.

This work was supported in part by the U.S. National Science Foundation (Grant G5106). We are indebted for the awards of predoctoral research fellowships by the General Electric Fund (to T. D. C.) and by the Natvar Corporation (to S. L. S.). We thank Mr. Luther Herrick for the proton nuclear magnetic resonance measurements.

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151. *Nitroethylene and Some Indolylmagnesium Iodides.*

By R. M. ACHESON and A. R. HANDS.

A NUMBER of indoles [1,2] are known to react directly with nitroethylene, yielding the corresponding 3-2′-nitroethylindoles, and it is stated [1] that indolylmagnesium iodide gives a better yield of 3-2′-nitroethylindole than indole itself. The reaction of nitroethylene with three indolylmagnesium iodides was therefore examined, as the products were needed in another connexion.

5,6-Dimethoxy-1-indolylmagnesium iodide with nitroethylene gave the corresponding 3-2′-nitroethylindole derivative, as proved by reduction to 5,6-dimethoxytryptamine which was compared, as the picrate, with a specimen prepared by another method.[3] 3-Methyl-1-indolyl- and 5-benzyloxy-1-indolyl-magnesium iodide gave 3-methyl-1-2′-nitroethylindole and 5-benzyloxy-1,3-di-2′-nitroethylindole respectively. The isomeric indolenine structures for these adducts are excluded by their insolubility in acid and by their ultraviolet absorption spectra.

Experimental.—Deactivated alumina was prepared by shaking alumina (Spence, grade " H," 2 kg.) with acetic acid (10 ml.) and water (90 ml.). Nitroethylene, b. p. 40—45°/90 mm., was prepared by Buckley and Scaife's method.[4] 5-Benzyloxyindole-2-carboxylic acid was prepared by Boehme's method; [5] it gave 5-benzyloxyindole on decarboxylation,[6] b. p. 200—210°/0·1 mm., m. p. 104° (from ether). 5,6-Dimethoxyindole was obtained by the method of Huebner, Troxell, and Schroeder,[3] and had m. p. 156° after chromatography on deactivated alumina with benzene as the eluent. The ultraviolet absorption spectra were measured for MeOH solutions, and the infrared spectra for Nujol mulls.

3-*Methyl*-1-2′-*nitroethylindole.* 3-Methyl-1-indolylmagnesium iodide was prepared by Baker's method [7] from magnesium (0·86 g.), ethyl iodide (5·61 g.), and skatole (4·72 g.) in ether (30 ml.). The solution was stirred and cooled in an ice-bath, and nitroethylene (2·63 g.) in ether

[1] Noland and Hartman, *J. Amer. Chem. Soc.*, 1954, **76**, 3227.
[2] Lange, *Diss. Abs.*, 1959, **20**, 1172; Noland and Horden, *J. Org. Chem.*, 1959, **24**, 894.
[3] Huebner, Troxell, and Schroeder, *J. Amer. Chem. Soc.*, 1953, **75**, 5887.
[4] Buckley and Scaife, *J.*, 1947, 1471.
[5] Boehme, *J. Amer. Chem. Soc.*, 1953, **75**, 2502.
[6] Stoll, Troxler, Peyer, and Hoffman, *Helv. Chim. Acta*, 1955, **38**, 1452.
[7] Baker, *J.*, 1946, 461.

(20 ml.) was added dropwise during 15 min. A yellow solid separated. The mixture was stirred for 1 hr. at room temperature, and was then refluxed for 1 hr.; the solid became brown and some brown fumes were evolved. After cooling to 0° the mixture was added with stirring to acetic acid (30 ml.) and water (100 ml.). The aqueous layer was separated, and was basified with an excess of solid sodium carbonate. The ether layer was shaken with a saturated solution of sodium carbonate until gas evolution ceased. The original aqueous layer and the sodium carbonate washings were extracted with ether, and the extracts were added to the original washed ether layer. The combined ether solutions were washed with water, dried ($MgSO_4$), and evaporated on the water-bath. The dark brown, tarry residue was chromatographed on deactivated alumina (250 g.) from benzene. The first eluate (600 ml.) yielded skatole (0·78 g., 17%), m. p. 95°. The second (500 ml.) gave 3-*methyl*-1-2′-*nitroethylindole* (0·06 g., 8%), pale yellow prisms (from ether), m. p. 85° (Found: C, 64·4; H, 5·7; N, 13·8. $C_{11}H_{12}N_2O_2$ requires C, 64·7; H, 5·9; N, 13·7%), $\nu_{max.}$ 1520 and 1340 cm.$^{-1}$ (NO_2), $\lambda_{max.}$ 224, 277, 285, and 295 (infl.) mμ (log ε 4·77, 3·98, 3·99, 3·91). The *picrate* separated from ethanol as dark red needles with a bronze reflex, m. p. 105° (Found: C, 46·6; H, 3·4; N, 16·1. $C_{17}H_{15}N_5O_8$ requires C, 47·1; H, 3·5; N, 16·2%). Further elution with ether (2·5 l.) gave a brown oil (1·16 g.).

1-2′-*Aminoethyl*-3-*methylindole*. 3-Methyl-1-2′-nitroethylindole (1·0 g.) in absolute ethanol (150 ml.) and 5% palladised charcoal (1·0 g.) was shaken for 2 hr. under hydrogen at 2 atm. Distillation of the filtrate gave 1-2′-*aminoethyl*-3-*methylindole* (0·66 g., 77%), b. p. 130—133° (bath)/0·3 mm., as a colourless oil, $n_D^{15·5}$ 1·6010, rapidly darkening in the air (Found: C, 75·8; H, 7·9; N, 15·6. $C_{11}H_{14}N_2$ requires C, 75·8; H, 8·1; N, 16·1%). The *picrate* formed scarlet prisms (from ethanol), m. p. 222° (decomp.) (Found: C, 51·0; H, 4·3; N, 17·6. $C_{17}H_{17}N_5O_7$ requires C, 50·6; H, 4·3; N, 17·4%).

5-*Benzyloxy*-1,3-*di*-2′-*nitroethylindole*. Nitroethylene (3·65 g.) in ether (20 ml.) was added dropwise to a stirred ice-cooled suspension of 5-benzyloxy-1-indolylmagnesium iodide, prepared from 5-benzyloxyindole (11·15 g.), ethyl iodide (7·80 g.), and magnesium (1·20 g.) in ether (100 ml.). The mixture was stirred at room temperature for 1 hr., refluxed for 1 hr., cooled for 1 hr., and poured with stirring into acetic acid (50 ml.) and water (150 ml.). The mixture was worked up as for 3-methyl-1-2′-nitroethylindole, and the tarry product was chromatographed on deactivated alumina (250 g.). Elution with benzene (2 l.) gave 5-benzyloxyindole (5·83 g., 52%), m. p. 103—104°. Further elution with ether (500 ml.) gave 5-*benzyloxy*-1,3-*di*-2′-*nitroethylindole* (0·43 g., 2·3%), which crystallised from ethanol in needles, m. p. 153° (Found: C, 62·0; H, 5·3; N, 11·5. $C_{19}H_{19}N_3O_5$ requires C, 61·8; H, 5·2; N, 11·4%), $\nu_{max.}$ 1560 and 1377 cm.$^{-1}$ (NO_2), $\lambda_{max.}$ 220, 276, 302, 312 (infl.) mμ (log ε 4·55, 3·91, 3·74, 3·66). Further elution with ether (500 ml.) gave a brown oil (0·19 g.).

5,6-*Dimethoxy*-3,2′-*nitroethylindole*. 5,6-Dimethoxy-1-indolylmagnesium iodide, obtained from 5,6-dimethoxyindole (10·27 g.), ethyl iodide (9·05 g.), and magnesium (1·39 g.) in ether (100 ml.), was stirred and cooled in an ice-bath during the addition of a solution of nitroethylene (4·23 g.) in ether (50 ml.). The mixture was worked up as in the previous preparation, and the tarry product was chromatographed on deactivated alumina (250 g.). Elution with benzene–ether (9 : 1 v/v; 4·5 l.) gave 5,6-dimethoxyindole (3·43 g., 33%), m. p. 156°. Elution with ether (500 ml.) then gave a material of m. p. 129—146° (0·34 g.). Further elution with ether (1·5 l.) gave 5,6-dimethoxy-3-2′-nitroethylindole (1·42 g., 10%), orange prisms (from benzene), m. p. 133° (Found: C, 57·9; H, 5·4; N, 11·1. $C_{12}H_{14}N_2O_4$ requires C, 57·6; H, 5·6; N, 11·2%), $\nu_{max.}$ 3290 (NH), and 1537 and 1370 cm.$^{-1}$ (NO_2), $\lambda_{max.}$ 220, 279 (infl.), 296, 301, and 306 (infl.) mμ (log ε 4·50, 3·75, 3·94, 3·92). The *picrate* separated from ethanol as purple needles with a bronze reflex, m. p. 127—128° (decomp.) (Found: C, 45·5; H, 3·7; N, 14·5. $C_{18}H_{17}N_5O_{11}$ requires C, 45·1; H, 3·6; N, 14·6%). Further elution with ether (2 l.) gave an oil (0·73 g.).

5,6-*Dimethoxytryptamine*. 5,6-Dimethoxy-3-2′-nitroethylindole (0·3 g.), 5% palladised charcoal (0·3 g.), and ethanol (100 ml.) were shaken for 1 hr. under hydrogen at 5 atm. Filtration and distillation at 190—200° (bath)/0·05 mm. gave a colourless oil (0·19 g., 72%) which was identified as 5,6-dimethoxytryptamine by conversion into the picrate, m. p. and mixed m. p. 223—224° (decomp.). The infrared absorption spectra of the two specimens were identical.

We thank Dr. E. Schlittler for the authentic 5,6-dimethoxytryptamine picrate and the Mental Health Research Fund for a grant for the provision of scientific assistance.

Department of Biochemistry, University of Oxford. [*Received, June 27th*, 1960.]

152. 5-*Hydroxyskatole.*

By R. M. Acheson and A. R. Hands.

5-Hydroxyskatole, m. p. 116°, required for chromatographic studies, has been synthesised for the first time by a structurally unequivocal route, by hydrogenation of 5-benzyloxygramine over platinum. The reduction of 5-benzyloxygramine to 5-benzyloxyskatole by zinc dust and sodium hydroxide, a procedure used earlier [1] for the conversion of gramine into skatole, followed by hydrogenolysis of the 5-benzyloxyskatole, was much less satisfactory. A compound described as 5-hydroxyskatole, m. p. 108—109°, has been obtained [2] from 2,3-dihydroskatole and potassium nitrosodisulphonate, but no analytical data or structure proof was given.

Experimental.—*5-Hydroxyskatole.* (i) 5-Benzyloxygramine (0·50 g.), Adams platinum catalyst (0·30 g.), and methanol (50 ml.) were shaken for 5 hr. under hydrogen at 5 atm. Filtration, evaporation, and recrystallisation of the residue from 1 : 3 v/v ether–light petroleum (b. p. 40—60°) gave 5-*hydroxyskatole* (0·19 g., 72%), m. p. 116° (Found: C, 73·1; H, 5·7; N, 9·8. C_9H_9NO requires C, 73·4; H, 6·2; N, 9·5%). (ii) 5-Benzyloxyskatole (100 mg.), 5% palladised charcoal (100 mg.), and ethanol (30 ml.) were shaken for 24 hr. under hydrogen at 5 atm. Filtration and evaporation of the filtrate gave a tarry residue, which on 3 recrystallisations from ether–light petroleum (as above) gave 5-hydroxyskatole (8 mg., 13%), m. p. and mixed m. p. 116°, 115—116°.

5-Benzyloxyskatole. Sodium hydroxide (2·0 g.) in water (16 ml.) was added to 5-benzyloxygramine (1·37 g.) in methanol (26 ml.), and the mixture was heated to boiling. Zinc dust (1·6 g.) was added during 2 hr. with stirring. Heating and stirring were continued for 12 hr., an oily lower layer separating. Methanol was removed on the water-bath, and the cooled residue was extracted with ether (3 × 100 ml.). The extracts were dried (Na_2SO_4) and on evaporation gave an oil, which was chromatographed from benzene on alumina (150 g.) deactivated by acetic acid (0·75 ml.) and water (6·7 ml.). The first eluate (250 ml.) gave an oil (10 mg.); further elution (250 ml.) gave 5-*benzyloxyskatole* (0·76 g., 64%), crystallising from light petroleum (b. p. 40—60°) in white needles, m. p. 118° (Found: C, 81·0; H, 6·3; N, 5·7. $C_{16}H_{15}NO$ requires C, 81·0; H, 6·4; N, 5·9%). The *picrate* separated from methanol as crimson needles with a bronze reflex, m. p. 164° (Found: C, 57·0; H, 3·8; N, 11·8. $C_{22}H_{18}N_4O_8$ requires C, 56·7; H, 3·9; N, 12·0%). Further elution with benzene (2 l.) gave a resin (0·33 g.).

We thank the Mental Health Research Fund for a Grant for the provision of scientific assistance.

Department of Biochemistry, University of Oxford. [*Received, July 25th,* 1960.]

[1] Terent'ev, Dzbanovskii, and Favorskaya, *Zhur. obshchei Khim.*, 1953, **23**, 2035.
[2] Teuber and Staiger, *Chem. Ber.*, 1956, **89**, 489.

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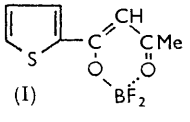
153. *So-called "2-Triacetylthiophen" (a Boron Compound).*

By G. M. Badger and Jenneth M. Sasse.

Acetylation of 2-acetylthiophen with acetic anhydride and boron trifluoride has been reported [1] to give a compound which (on the basis of a sulphur analysis and the fact that it gave thiophen-2-carboxylic acid on oxidation) was named "2-triacetylthiophen."



(I)

The preparation of this compound has been repeated, and it has been identified as 3-oxo-1-2′-thienylbut-1-enyloxyboron difluoride (I) by more complete analysis and by comparison with a specimen prepared by treatment of 1-2′-thienylbutane-1,3-dione [2] with boron trifluoride. Several other examples of boron difluoride complexes with β-diketones have been reported.[3]

[1] Hartough and Kosak, *J. Amer. Chem. Soc.*, 1948, **70**, 867.
[2] Harris and Levine, *J. Amer. Chem. Soc.*, 1948, **70**, 3360.
[3] Morgan and Tunstall, *J.*, 1924, **125**, 1963; Young, Frostick, Sanderson, and Hauser, *J. Amer. Chem. Soc.*, 1950, **72**, 3635; Hauser, Frostick, and Man, *ibid.*, 1952, **74**, 3231; McOmie and Tute, *J.*, 1938, 3226.

Experimental.—1-2′-*Thienylbutane*-1,3-*dione*. Harris and Levine's method [2] was followed, except that after the decomposition of the copper salt, the ether extract was evaporated and the residue extracted with light petroleum (b. p. 40—60°). The extract gave yellow plates, m. p. 34°. The copper salt formed green needles, m. p. 232—234° (lit.,[2] m. p. 228—230°).

3-*Oxo*-1,2′-*thienylbut*-1-*enyloxyboron difluoride*. (i) Hartough and Kosak's method [1] was followed, except that the boron trifluoride–acetic acid complex was used instead of boron trifluoride–ether complex (half-scale; yield 8 g.; m. p. 172°). The analytical sample, after sublimation and recrystallisation from benzene, had m. p. 174—175° (lit.,[1] m. p. 176—177°) and this *product* gave a positive qualitative test for boron (Found: C, 44·4; H, 3·5; S, 14·7; F, 17·1. $C_8H_7BF_2O_2S$ requires C, 44·5; H, 3·3; S, 14·9; F, 17·6%) (previous analysis [1]: Found, S, 14·9. $C_{10}H_{10}O_3S$ requires C, 57·2; H, 4·8; S, 15·3%).

(ii) 1-2′-Thienylbutane-1,3-dione (134 mg.) was dissolved in glacial acetic acid (2 c.c.), a 40% solution (1 ml.) of boron trifluoride in acetic acid was added, and the mixture shaken. A yellow precipitate appeared almost immediately, but the mixture was set aside for ½ hr. The solid was collected, and a further quantity was isolated after treatment of the mother-liquor with dilute sodium acetate solution. The product crystallised from benzene as orange-yellow needles of the difluoride (125 mg., 73%), m. p. and mixed m. p. 174—175°. The infrared spectra of the two samples were superimposable.

We thank Mr. A. G. Moritz for the infrared spectra. Microanalyses were carried out at the C.S.I.R.O. Microanalytical Laboratory, Melbourne.

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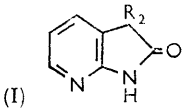
154. 2,3-*Dihydro*-3,3-*dimethyl*-1H-1,7-*diazaindan*-2-*one*.

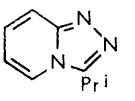
By G. E. FICKEN and J. D. KENDALL.

ALTHOUGH oxindoles have been very thoroughly examined,[1] very little is known of their aza-analogues in which the six-membered ring is pyridine instead of benzene: the only reported preparation of such a compound is of 2,3-dihydro-1,7-diazaindan-2-one [2] (I; R = H) (2,3-dihydro-1*H*-pyrrolo[2,3-*b*]pyridin-2-one).

We have found that a compound which appears to be 2,3-dihydro-3,3-dimethyl-1*H*-1,7-diazaindan-2-one (I; R = Me) is obtained in small yield by heating *N*-isobutyryl-*N*′-2-pyridylhydrazine with calcium oxide, analogously to the Brunner oxindole synthesis.[3] The infrared spectrum of the compound is consistent with an azaoxindole formulation.



(I)



(II)

The low yield can be ascribed partly to the weak susceptibility of the pyridine ring to electrophilic substitution, and partly to the formation of the pyridotriazole (II). Although the latter was not isolated in the present reaction, it is formed when the isobutyrylhydrazine is heated alone at 250°.

We have been unable to prepare azaoxindoles by the use of the oxindole syntheses of Stollé [4] (2-α-bromo-*N*-methylisobutyramidopyridine heated with aluminium chloride) or of Hinsberg [5] (2-methylaminopyridine treated with glyoxal sodium bisulphite).

Experimental.—N-*Isobutyryl*-N′-2-*pyridylhydrazine*. This *compound* was prepared in 44% yield from isobutyric anhydride and 2-hydrazinopyridine, according to the directions for

[1] Elderfield, "Heterocyclic Compounds," John Wiley and Sons, Inc., New York, 1952, Vol. III, pp. 126—186.
[2] Kägi, *Helv. Chim. Acta*, 1941, **24**, 141E.
[3] Brunner, *Monatsh.*, 1906, **27**, 1183.
[4] Stollé, *Ber.*, 1914, **47**, 2120.
[5] Hinsberg and Rosenzweig, *Ber.*, 1894, **27**, 3253.

the acetylation of the hydrazine.[6] It formed plates, m. p. 135—137°, from benzene (Found: C, 60·2; H, 7·0. $C_9H_{13}N_3O$ requires C, 60·3; H, 7·3%).

2,3-*Dihydro*-3,3-*dimethyl*-1H-1,7-*diazaindan*-2-*one*. The above hydrazine (10 g.) and freshly ignited calcium oxide (20 g.) were mixed and heated in a nitrogen stream at 290—300°; slow evolution of ammonia occurred. After 2 hr. the mixture was cooled and dissolved in concentrated hydrochloric acid and the solution was extracted with chloroform continuously for 24 hr. The residual aqueous solution was treated with excess of ammonia, saturated with ammonium chloride, and, after filtration, continuously extracted with chloroform. The extracts were evaporated to leave a brown oil which was treated in ethanol with excess of ethanolic picric acid. Recrystallisation from ethanol and then ethyl acetate (twice) gave the *diazaindanone picrate* (0·74 g.), yellow plates, m. p. 231—232° (Found: C, 46·1, 46·4; H, 3·1, 3·5; N, 17·55. $C_{15}H_{13}N_5O_8$ requires C, 46·0; H, 3·35; N, 17·9%). The picrate was stirred with 0·5N-sodium hydroxide (50 ml.) until a homogeneous solution was obtained. Continuous extraction with chloroform and evaporation of the extract yielded a solid (0·29 g.) which after two crystallisations from ethyl acetate gave 2,3-*dihydro*-3,3-*dimethyl*-1H-1,7-*diazaindan*-2-*one*, colourless plates, m. p. 178—179° (Found: 67·2; H, 6·4; N, 17·6. $C_9H_{10}N_2O$ requires C, 66·65; H, 6·2; N, 17·3%). The infrared spectrum (Nujol mull) showed bands at 3100m (NH stretch), 1940w, 1720s (C=O stretch), 1610s (NH bend), 1442w, 1430m, 1410m, 1358w, 1328m, 1300w, 1278w, 1258w, 1236m, 1200s, 1154s, 1120m, 1086m, 1056w, 1038m, 1016w, 978w, 948m, 903w, 820m, 800m, 781s (CH out-of-plane, 3 adjacent H) cm.$^{-1}$.

3-*Isopropyl*-1,2,3a-*triazaindene* (II). *N*-Isobutyryl-*N'*-2-pyridylhydrazine (9·1 g.) was heated at 250° for 30 min., water being evolved. Distillation of the residue gave 3-*isopropyl*-1,2,3a-*triazaindene* (7·9 g.), b. p. 144°/0·2 mm., m. p. 44° (Found: C, 66·9; H, 6·8. $C_9H_{11}N_3$ requires C, 67·0; H, 6·9%). The *picrate*, yellow needles from methanol, had m. p. 201° (Found: C, 46·2; H, 3·5; N, 21·3. $C_{15}H_{14}N_6O_7$ requires C, 46·2; H, 3·6; N, 21·5%). The infrared spectrum of the base (supercooled liquid) had bands at 3450w, 3110w, 3000m (CH stretch), 1680w, 1645m (C=C or C=N stretch), 1580w, 1535w, 1515s, 1464m, 1392m, 1372m, 1344 (last 3 CH bend), 1296w, 1274m, 1186w, 1142w, 1102w, 1060m, 1042m, 1000w, 926w, 888w, 837w, 779w, 764s, 749s, 714m, 690m cm.$^{-1}$.

We thank Mr. L. R. Brooker for the infrared spectra measurements, and for valuable discussions on their interpretation, also Miss J. Connor for the microanalyses.

RENWICK LABORATORY, ILFORD LIMITED,
ILFORD, ESSEX. [*Received, July 12th*, 1960.]

[6] Fargher and Furness, *J.*, 1915, **107**, 688.

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155. 2,4'-*Diphenylbiphenyl* [op'-*Quaterphenyl*].

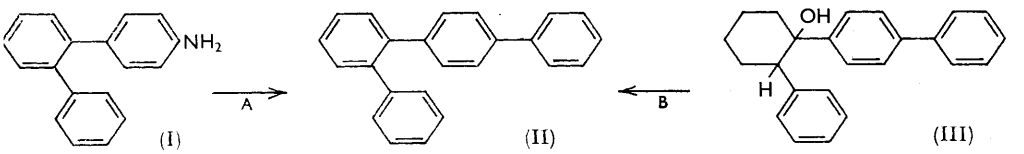
By D. H. HEY, M. J. PERKINS, and GARETH H. WILLIAMS.

THE preparation of 2,4'-diphenylbiphenyl (*op'*-quaterphenyl) has been reported by Dale,[1] who obtained it by means of an Ullmann reaction between 2- and 4-iodobiphenyl and recorded m. p. 117·5—118°. More recently Wiley and Wakefield[2] reported its preparation by tetrazotisation of 2,4'-diaminobiphenyl and decomposition of the derived tetrazonium hydroxide in the presence of benzene; they obtained the same compound from the decomposition of 2,4'-di(acetylnitrosoamino)biphenyl in benzene and recorded m. p. 209—210°. We required an authentic specimen of this hydrocarbon for reference purposes and have obtained it by two new and unambiguous routes. Our product has properties in agreement with those reported by Dale [1] but different from those reported by Wiley and Wakefield.[2]

o-Terphenyl was nitrated in the 4-position,[3] and the nitro-compound was reduced to

[1] Dale, *Acta Chem. Scand.*, 1957, **11**, 640, 650.
[2] Wiley and Wakefield, *J. Org. Chem.*, 1960, **25**, 132.
[3] Allen and Burness, *J. Org. Chem.*, 1949, **14**, 175.

4-amino-*o*-terphenyl[3] (I), acetylated, and nitrosated. The resulting 4-(acetylnitrosoamino)-*o*-terphenyl was allowed to decompose in benzene solution, and gave 2,4′-diphenylbiphenyl (II), m. p. 120—120·5° (method A). In the second synthesis the secondary alcohol



(III) from the reaction of 2-phenylcyclohexanone[4] with 4-biphenylylmagnesium bromide was dehydrated and dehydrogenated to yield 2,4′-diphenylbiphenyl (II), m. p. 119—120° (method B). The melting point of this specimen (119—120°) was not depressed on admixture with the sample prepared by method A.

Experimental.—M. p.s are corrected.

Method A. *o*-Terphenyl was nitrated by Allen and Burness's method,[3] to give 4-nitro-*o*-terphenyl, m. p. 110—114° (lit.,[3] 116°), which was reduced with tin and hydrochloric acid to the corresponding amino-compound, m. p. 117·5—118·5° (lit.,[3] 117—118°). The benzoyl derivative of this amine after crystallisation from aqueous methanol had m. p. 187—188° (lit.,[5] 175°) (Found: C, 85·9; H, 5·45. Calc. for $C_{25}H_{19}NO$: C, 86·0; H, 5·45%). 4-Amino-*o*-terphenyl (4·05 g.) was treated with acetyl chloride in pyridine to give 4-*acetamido*-o-*terphenyl* (4·34 g.) in needles, m. p. 159·5—160·5° (from aqueous methanol) (Found: C, 84·0; H, 6·1. $C_{20}H_{17}NO$ requires C, 83·75; H, 6·0%). Nitrosyl chloride (1·5 g.) in acetic anhydride (10 ml.) was added, slowly and with stirring, to a solution of this acetyl derivative (4·0 g.) in glacial acetic acid (25 ml.) and acetic anhydride (15 ml.) at 0° containing phosphorus pentoxide (0·5 g.), and fused sodium acetate (4 g.). The solution was stirred for 15 min. and then poured into stirred ice-water (500 ml.). The mixture was stirred at 0° for 1 hr., and the yellow precipitate filtered off. This *N*-nitroso-derivative decomposed suddenly at about 90°, without melting. The entire product was stirred with cooled "AnalaR" benzene (150 ml.) and anhydrous magnesium sulphate (20 g.), while the temperature was allowed to rise to 20°. Stirring was continued for 48 hr., after which the solution was boiled for 10 min., filtered, and then washed with successive portions of concentrated sulphuric acid until both layers were almost colourless. The organic layer was washed with aqueous sodium hydrogen carbonate, and water (twice), and dried ($MgSO_4$). The solvent was distilled off, and the residue chromatographed on alumina, which was then eluted with 3 : 1 light petroleum (b. p. 40—60°)–benzene. Evaporation of the early fractions of the eluate left a solid (1·53 g.), which was crystallised to constant m. p. (120—120·5°) from light petroleum (b. p. 40—60°) (Found: C, 94·0; H, 5·9. Calc. for $C_{24}H_{18}$: C, 94·1; H, 5·9%). The infrared absorption spectrum of the product in a Nujol mull agreed with that reported by Dale.[1] The ultraviolet absorption in ethanol showed maxima at 249 mμ (ε 2·72 × 10^4) and 277 mμ (ε 2·33 × 10^4). Dale [1] reported m. p. 117·5—118°, $\lambda_{max.}$ (in hexane) 248 mμ (ε 2·72 × 10^4), 276 mμ (ε 2·31 × 10^4).

Method B. 4-Bromobiphenyl (9 g.) was treated with magnesium (1 g.) in tetrahydrofuran (12 ml.) under nitrogen. After the initial reaction had subsided, the solution was boiled under reflux for ½ hr. 2-Phenylcyclohexanone, prepared by Newman and Farbman's method,[4] m. p. 60—61° (lit.,[6] 61°) [from light petroleum (b. p. 40—60°)] (Found: C, 82·7; H, 8·1. Calc. for $C_{12}H_{14}O$: C, 82·7; H, 8·1%) (6 g.), in tetrahydrofuran (12 ml.) was added slowly to the Grignard reagent, and the mixture was refluxed under nitrogen for 3 hr. The resulting solution was treated with excess of N-hydrochloric acid and extracted with benzene (2 × 20 ml.). The benzene extract was dried ($MgSO_4$), and the solvent removed under reduced pressure to give an oil, which was boiled under reflux, with stirring, for 5 hr. with 85% formic acid (20 ml.). The resulting solution was cooled and added to water (150 ml.); a white solid separated, which, after crystallisation from a minimum of ethanol, had m. p. 100—120° (7 g.). Crystallisation to constant m. p. from ethanol gave a compound A in colourless needles, m. p. 135—136°. Concentration of the mother-liquors from these crystallisations gave a solid melting in the

[4] Newman and Farbman, *J. Amer. Chem. Soc.*, 1944, **66**, 1550.
[5] Allen and Pingert, *J. Amer. Chem. Soc.*, 1942, **64**, 2639.
[6] Levy and Sfiras, *Bull. Soc. chim. France*, 1931, **49**, 1830.

range 90—115°, but further concentration gave a minor product B as prisms which crystallised to constant m. p. (101·5—102·5°) from ethanol. Both compounds analysed correctly for a phenylbiphenylylcyclohexene, and further separation was not attempted (Found, for A: C, 92·8; H, 7·25. For B: C, 92·8; H, 7·1. Calc. for $C_{24}H_{22}$: C, 92·85; H, 7·15%). The two compounds are probably isomers differing in the position of the double bond in the non-aromatic ring. A solution of the mixed product (5 g.) and chloranil (7 g.) in xylene (35 ml.) was boiled under reflux for 16 hr. The solution was cooled and the solid tetrachloroquinol which separated (m. p. 234—238°) was removed. The filtrate was combined with benzene washings of the quinol, and extracted with 2N-sodium hydroxide (three times), water, and repeatedly with concentrated sulphuric acid until the organic layer was pale yellow. This was then washed again with water, aqueous sodium hydroxide (twice, with filtration to remove a trace of solid), and finally with water (twice). The solution was then dried ($MgSO_4$), and the solvent distilled off at reduced pressure, leaving a brown oil. This was dissolved in light petroleum (b. p. 40—60°) (50 ml.) and cooled at 0° overnight. Clusters of crystals tinged with red separated together with a powdery precipitate which was removed by decantation and discarded. The crystals had m. p. 116—119°, alone and on admixture with 2,4′-diphenylbiphenyl prepared by method A, and showed an identical infrared absorption spectrum. Further recovery of the compound from the mother-liquors gave a total yield of 2·4 g. Treatment with charcoal in methanol raised the m. p. to 119—120°, but did not completely remove the red colour (Found: C, 94·2; H, 5·75. Calc. for $C_{24}H_{18}$: C, 94·1; H, 5·9%).

Thanks are accorded to the Department of Scientific and Industrial Research for the award of a Studentship to M. J. P.

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[*Received, July 14th,* 1960.]

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156. *Molybdenum*(II) *Complexes containing Triphenyl-phosphine Oxide or -arsine Oxide*

By J. C. SHELDON.

THE oxides of triphenyl-phosphine and -arsine readily form two types of chloromolybdenum(II) complex (M = P or As): non-electrolytes, $[(Mo_6Cl_8)Cl_4(Ph_3MO)_2]$, and electrolytes, $[(Ph_3MO)_nH]_2[(Mo_6Cl_8)Cl_6]$. The non-electrolytes are probably octahedral complexes of the (Mo_6Cl_8) polynucleus and are non-hygroscopic and stable up to 200° *in vacuo*. Although these complexes dissociate in nitrobenzene solution, giving only half the required formula weight, they can be recovered unchanged from solution by addition of light petroleum. The M–O stretching frequencies appear at 1061 and 852 $cm.^{-1}$ in the phosphine oxide and the arsine oxide compound respectively, compared with 1185 and 879 $cm.^{-1}$ in the corresponding free oxide. This shift to lower frequencies is indicative of co-ordination *via* the M–O oxygen atom.

The electrolytes are derivatives of the acid $H_2[(Mo_6Cl_8)Cl_6]$, referred to as chloromolybdic(II) acid, and are listed in the Table along with their empirical formulæ, molar conductivities at 10^{-3}M, and cryoscopic molecular weights in nitrobenzene, and proposed structures. It is likely that chloromolybdic(II) acid is a strong acid in view of the size

Empirical formula	Proposed structure	Λ_m	M	Formula wt./M
$H_2[(Mo_6Cl_8)Cl_6],4Ph_3PO$	$[(Ph_3PO)_2H]_2[(Mo_6Cl_8)Cl_6]$	52	840	2·6
$H_2[(Mo_6Cl_8)Cl_6],6Ph_3PO$	$[(Ph_3PO)_2H]_2[(Mo_6Cl_8)Cl_6],2Ph_3PO$	49	650 *	4·2
$H_2[(Mo_6Cl_8)Cl_6],2Ph_3AsO$	$[Ph_3AsOH]_2[(Mo_6Cl_8)Cl_6]$	43	590 *	2·9
$H_2[(Mo_6Cl_8)Cl_6],4Ph_3AsO$	$[(Ph_3AsO)_2H]_2[(Mo_6Cl_8)Cl_6]$	43	810 *	2·9

* Recovered unchanged from solution.

and structure of the chloromolybdate(II) ion, and therefore the electrolytes are best regarded as chloromolybdate(II) salts. Thus it is convenient to formulate $H_2[(Mo_6Cl_8)Cl_6],2Ph_3AsO$ as a quaternary arsonium salt $[Ph_3As{\cdot}OH]_2[(Mo_6Cl_8)Cl_6]$.

However, a problem of formulation arises for the other chloromolybdate(II) salts in that they possess an oxide to proton ratio greater than 1. It is suggested that the cations in these salts are hydrogen-bonded complexes, *e.g.*, $[Ph_3P(As)OH\cdots OP(As)Ph_3]^+$, which may be related to the hydrogen dihalide ions, $[XHX]^-$, bv the oxygen atom of the $P(As)^+–O^-$ group behaving as a pseudohalide ion. The oxide to proton ratio found in these salts appears to be governed by that ratio in the preparative solutions, for the lower ratios are obtained from the stronger acid solutions. Furthermore, as arsine oxides are stronger bases than phosphine oxides,[1] the arsine oxide salt series tends to have lower oxide to proton ratios than the phosphine series. The proposed complex cations appear to be stable in nitrobenzene solution, as conductivity and molecular-weight studies show that the salts are 2 : 1 electrolytes. However, the compound $H_2[(Mo_6Cl_8)Cl_6],6Ph_3PO$ dissociates into more than 3 solute particles per molecule and it is necessary to formulate it as $[(Ph_3PO)_2H]_2[(Mo_6Cl_8)Cl_6],2Ph_3PO$. Salts of triphenyl-phosphine oxide,[2,3] and -arsine oxide [4] have been found previously, although there is only one report of oxide to proton ratios exceeding unity.[3]

The P(As)–O stretching bands undergo pronounced and complex changes when the oxides form chloromolybdate(II) salts. The P–O stretching band of the free oxide (1185 cm.$^{-1}$) is absent from the spectra of the phosphine oxide salts and the following bands are found in addition to the normal phosphine oxide absorption in the range 1250—770 cm.$^{-1}$: $H_2[(Mo_6Cl_8)Cl_6],4Ph_3PO$, 1149 (weak) and 955 (broad and strong); $H_2[(Mo_6Cl_8)Cl_6],6Ph_3PO$, 1132 (strong) and 1068 cm.$^{-1}$. In a like manner the As–O stretching band (879 cm.$^{-1}$) is absent from the spectra of the arsine oxide compounds, but the compound $H_2[(Mo_6Cl_8)Cl_6],2Ph_3AsO$ has additional bands at 872 (only moderately strong) and 770 cm.$^{-1}$ (strong), and the compound $H_2[(Mo_6Cl_8)Cl_6],4Ph_3AsO$ probably has an additional band almost coincident with a normal strong triphenylarsine oxide band at 740 cm.$^{-1}$.

Experimental.—Molar conductivities, cryoscopic molecular weights, and analyses were determined as previously described.[5] The infrared spectra were recorded by a Grubb-Parsons type GS2A double-beam grating spectrometer from Nujol mulls.

Triphenylphosphine oxide. The commercial material was adequate for preparative purposes and a resublimed sample had satisfactory m. p. and analysis.

Triphenylarsine oxide. The arsine oxide hydrate (obtained by treatment of triphenylarsine with aqueous hydrogen peroxide) proved suitable for the preparation of the complexes below. Vacuum-sublimed samples of the oxide hydrate analysed closely for the free arsine oxide and had melting ranges of 188—194° (lit.,[6] 190—191°) although they still showed some infrared absorption at 3380 and 1660 cm.$^{-1}$ characteristic of water.

General preparation of complexes. The non-electrolyte complexes, $[(Mo_6Cl_8)Cl_4(Ph_3MO)_2]$, may be obtained by heating the chloromolybdate(II) salts strongly *in vacuo* or, more conveniently, by mixing ethanolic solutions of the appropriate oxide and molybdenum(II) chloride and drying the precipitate *in vacuo*. The chloromolybdate(II) salts are precipitated or slowly crystallise from aqueous- or absolute-ethanolic solutions of the appropriate oxide and chloromolybdic(II) acid. The latter may be formed *in situ* from molybdenum(II) chloride, *i.e.*, Mo_6Cl_{12}, and 2 equiv. of hydrogen chloride. The particular salt obtained depends on the proportion of oxide to acid [both as chloromolybdic(II) acid and excess of hydrochloric acid] in the preparative solution; *e.g.*, the $4Ph_3AsO$ salt was given as an immediate precipitate on the addition of ethanolic chloromolybdic(II) acid to an excess of ethanolic arsine oxide, whereas the $6Ph_3PO$ salt separated slowly from an aqueous-ethanolic dilute hydrochloric acid solution of the phosphine oxide and chloromolybdic(II) acid. However, addition of excess of hydrochloric

[1] Nylén, *Z. anorg. Chem.*, 1941, **246**, 227.
[2] Michaelis and Soden, *Annalen*, 1885, **229**, 295.
[3] Pickard and Kenyon, *J.*, 1906, **89**, 262.
[4] La Coste and Michaelis, *Annalen*, 1880, **201**, 184; Michaelis, *ibid.*, 1902, **321**, 141; Steinkopf and Schwen, *Ber.*, 1921, **54**, 2791.
[5] Sheldon, *J.*, 1960, 1007.
[6] Jensen, *Z. anorg. Chem.*, 1943, **250**, 268.

acid to these two preparations gave the $2Ph_3AsO$ and $4Ph_3PO$ salts respectively. Analyses are given below.

Tetrachlorobis[triphenylphosphine(or arsine) oxide]octa-μ_3*-chlorohexamolybdenum*(II). Found, for *phosphorus compound*: C, 26·8; H, 2·1; Cl, 27·7. $C_{36}H_{30}Cl_{12}Mo_6O_2P_2$ requires C, 27·8; H, 1·9; Cl, 27·4%. Found, for *arsenic compound*: C, 26·8; H, 2·0; As, 9·1; Cl, 25·9. $C_{36}H_{30}As_2Cl_{12}Mo_6O_2$ requires C, 26·3; H, 1·8; As, 9·1; Cl, 25·9%.

Bis{hydrogenbis[triphenylphosphine(or arsine)oxide]}hexachloro-octa-μ_3*-chlorohexamolybdate*(II). Found, for the *phosphine oxide salt*: C, 39·7; H, 3·0; Cl, 22·7; Mo_6Cl_8, 41; P, 5·65. $C_{72}H_{62}Cl_{14}Mo_6O_4P_4$ requires C, 39·4; H, 2·8; Cl, 22·7; Mo_6Cl_8, 39; P, 5·65%. Found for the *arsine oxide salt*: C, 35·9; H, 3·0; Cl, 21·2; Mo, 24·0. $C_{72}H_{62}As_4Cl_{14}Mo_6O_4$ requires C, 36·5; H, 2·6; Cl, 21·0; Mo, 24·4%.

Bis[hydrogenbis(triphenylphosphine oxide)]hexachloro-octa-μ_3*-chlorohexamolybdate*(II)*-2-(triphenylphosphine oxide)*. Found: C, 47·4; H, 3·7; Cl, 18·2; Mo_6Cl_8, 32; P, 7·0. $C_{108}H_{92}Cl_{14}Mo_6O_6P_6$ requires C, 47·2; H, 3·35; Cl, 18·1; Mo_6Cl_8, 31; P, 6·8%.

Bis(hydroxotriphenylarsonium)hexachloro-octa-μ_3*-chloro-hexamolybdate*(II). Found: C, 25·4; H, 1·9; Cl, 28·8; Mo, 32·3. $C_{36}H_{32}As_2Cl_{14}Mo_6O_2$ requires C, 25·2; H, 1·85; Cl, 28·9; Mo, 33·6%.

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[*Received, July 21st,* 1960.]

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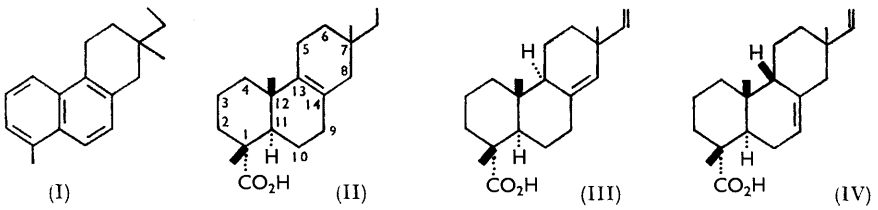
157. *Sandaraco- and Crypto-pimaric Acid.*

By J. W. APSIMON, B. GREEN, and W. B. WHALLEY.

OUR interest in diterpene acids has led us to examine the constitution of sandaraco- and crypto-pimaric acid.

Sandaracopimaric acid was originally isolated by Henry [1] and by Tschirch and Wolff.[2] Petru and Galik [3] recently demonstrated that this acid belongs to the pimaric acid series and claimed [4] that dehydrogenation of dihydrosandaracopimaric acid furnished the hydrocarbon (I), identical with that derived from dihydrodextropimaric acid.[5] They thus concluded that sandaraco- and dextro-pimaric acid had the same stereochemistry at $C_{(7)}$, but differed in the relative stereochemistry of the carboxyl groups at $C_{(1)}$.

In a re-examination of this problem we have isolated sandaracopimaric acid from a commercially available sandarac resin. The infrared absorption spectrum indicates the presence of a vinyl residue, which is readily saturated to furnish a dihydro-derivative ($\nu_{max.}$ 824 cm.$^{-1}$; >C=CH–). Dihydrosandaracopimaric acid is not isomerised by toluene-*p*-sulphonic acid in boiling benzene [6] but with hydrogen chloride in chloroform is converted into 7-allopimar-13(14)-en-15-oic acid [6] (II), thereby establishing that sandaraco- and isodextro-pimaric acid have the same configuration at positions 1, 7, 11, and 12.



We have previously shown [6] that dihydroisodextropimaric acid is isomerised to acid (II) by toluene-*p*-sulphonic acid in boiling benzene. Dihydropimaric acid is not isomerised under these conditions, from which it may be concluded that this reagent is specific for the

[1] Henry, *J.*, 1901, **79**, 1144.
[2] Tschirch and Wolff, *Archiv. Pharm.*, 1906, **244**, 684.
[3] Petru and Galik, *Coll. Czech. Chem. Comm.*, 1953, **18**, 717.
[4] Galik, Petru, and Kuthan, *Naturwiss.*, 1959, **46**, 322.
[5] Harris and Sanderson, *J. Amer. Chem. Soc.*, 1948, **70**, 2081.
[6] Green, Harris, and Whalley, *J.*, 1958, 4715.

isomerisation of 13β-pimar-8(14)-enes [and probably of 13β-9(14)-enes] to pimar-13(14)-enes. Thus sandaracopimaric acid has a 13α-hydrogen. Since dihydrodextro- and dihydroisodextro-pimaric acid have plain rotatory dispersion curves which are positive and negative, respectively,[7] and dihydrosandaracopimaric acid has a plain, positive, rotatory dispersion curve, sandaracopimaric acid has the structure (III).*

A reputedly homogeneous diterpene acid, cryptopimaric acid, has been isolated from *Cryptomeria japonica* [8] and from *Dacrydium biforme* and *D. kirkii*,[9] and its identity with isodextropimaric acid has been proposed,[10,11,12] despite considerable variation [12] between the specific rotations of crypto- and isodextro-pimaric acid and their various, respective derivatives. On the other hand, Bruun, Ryhage, and Stenhagen [13] have assigned structure (III), that now allocated to sandaracopimaric acid, to cryptopimaric acid.

Through the courtesy of Professor H. Imamura we have examined a small quantity (400 mg.) of cryptopimaric acid and have shown that it is a mixture. Hydrogenation of " cryptopimaric acid " furnishes " dihydrocryptopimaric acid " ($\nu_{max.}$ 824 cm.$^{-1}$; >C=CH–), from which a small quantity of dihydrosandaracopimaric acid was isolated. Isomerisation of " dihydrocroptopimaric acid " by toluene-*p*-sulphonic acid in benzene gives 7-allopimar-13(14)-en-15-oic acid (II) in high yield. The precursor of the acid (II) must be either dihydroisodextropimaric acid or the dihydro-derivative of Ukita's acid (IV).[14] Hence " cryptopimaric acid " is a mixture consisting predominantly of isodextropimaric and/or Ukita's acid (IV), together with smaller amounts of sandaracopimaric acid. The presence of other minor constituents could not be excluded.

Experimental.—Sandaracopimaric acid. Powdered sandarac resin (400 g.) was extracted by the method of Petru and Galik [3] to yield a gummy acid which was purified by chromatography on silica from benzene–ether (9 : 1). Thus obtained, sandaracopimaric acid separated from aqueous methanol in needles (1·1 g.), m. p. 170—171°, $[\alpha]_D^{19}$ −19·7° (Found: C, 79·1; H, 10·3. Calc. for $C_{20}H_{30}O_2$: C, 79·4; H, 10·0%). Petru and Galik [3] reported m. p. 173°.

Hydrogenation of sandaracopimaric acid (0·3 g.) in alcohol (25 ml.) containing palladium–charcoal (0·1 g.) occurred during 2 min., to yield dihydrosandaracopimaric acid, needles (from aqueous methanol) (0·2 g.), m. p. 176—178°, $[\alpha]_D^{19}$ +26·8° (Found: C, 78·7; H, 10·6. Calc. for $C_{20}H_{32}O_2$: C, 78·9; H, 10·6%).

A solution of dihydrosandaracopimaric acid (0·1 g.) in chloroform (25 ml.) was saturated with hydrogen chloride at −5° during 4 hr. Purification of the semicrystalline product by chromatography on silica, from benzene–light petroleum (b. p. 60—80°) (1 : 1) gave 7-allopimar-13(14)en-15-oic acid [6] which separated from aqueous methanol in prisms (0·05 g.), m. p. and mixed m. p. 110° and having the requisite infrared absorption spectrum. This acid is dimorphous and occasionally separates from aqueous methanol in prisms, m. p. 129°. The isomorphs are readily interconvertible by seeding.

Cryptopimaric acid. The cryptopimaric acid supplied by Professor Imamura had m. p. 160—162°, $[\alpha]_D$ −20°. Attempts to achieve any separation by crystallisation and by chromatography were unsuccessful. Hydrogenation of cryptopimaric acid (0·2 g.) in alcohol (25 ml.) containing palladium–charcoal (0·05 g.) occurred during 2 min. to yield " dihydrocryptopimaric acid," m. p. 160—180°, $[\alpha]_D^{19}$ +18° (Found: C, 78·6; H, 10·5. Calc. for $C_{20}H_{32}O_2$: C, 78·9; H, 10·6%). Chromatography of this acid (0·085 g.) from benzene, on silica, furnished dihydrosandaracopimaric acid (10 mg.), m. p. and mixed m. p. 176—178°, and having the requisite infrared absorption spectrum.

* After completion of this work we were informed by Dr. O. E. Edwards that he had reached the same conclusion by a different method. We thank Dr. Edwards for this information.

[7] Bose and Struck, *Chem. and Ind.*, 1959, 1628.
[8] Keimatsu, Ishiguro, and Fukuri, *J. Pharm. Soc. Japan*, 1937, **57**, 69.
[9] Hosking and Brandt, *Ber.*, 1935, **68**, 1313; Hosking, *New Zealand J. Sci. Tech.*, 1937, **19**, 208.
[10] Barton, " Progress in Organic Chemistry," Vol. I, p. 22, ed. Cook, 1952, Butterworths, London.
[11] Erdtman, " Chemistry of Carbon Compounds," Vol. IIB, p. 712, ed. Rodd, 1953, Elsevier, Amsterdam.
[12] Kondo, Imamura, and Suda, *Bull. Agric. Chem. Soc. Japan*, 1959, **23**, 233.
[13] Bruun, Ryhage, and Stenhagen, *Acta Chem. Scand.*, 1958, **12**, 789.
[14] Edwards and Howe, *Canad. J. Chem.*, 1959, **37**, 760.

Isomerisation of " dihydrocryptopimaric acid " (0·30 g.) in benzene (10 ml.) containing toluene-*p*-sulphonic acid (0·05 g.), on the steam-bath during 1 hr. furnished 7-allopimar-13(14)-en-15-oic acid (0·2 g.), m. p. and mixed m. p. 110°, and having the requisite infrared absorption spectrum and specific rotation. No other homogeneous product could be isolated.

We thank Dr. O. E. Edwards, Ottawa, for a specimen of dihydropimaric acid and Professor Carl Djerassi, Stanford, for the rotatory dispersion measurement on dihydrosandaracopimaric acid.

Rotations refer to ethanol solutions and the infrared absorption spectra to CCl_4 solutions (Perkin-Elmer Model 21 spectrophotometer).

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158. *Fission of Triphenylmethyl Derivatives of Secondary Cellulose Acetates by Hydrogen Bromide.*

By W. R. D. LEIGH.

THE degree of substitution (D.S.) in secondary cellulose acetate normally required for good solubility in acetone is about ~2·3. Products in this range made by the conventional method of hydrolysing the triacetate have 30—50% of the free hydroxyl groups in the primary positions.

Previous attempts by Malm *et al.*[1] to prepare secondary cellulose acetates with all the free hydroxyl groups in the primary 6-positions *via* the 6-triphenylmethyl derivatives were unsuccessful owing to acetyl migration detritylation; the products had about 30% of the free hydroxyl groups in the primary positions and were similar to those obtained in the conventional way.

Using hydrogen bromide in anhydrous acetic acid as the detritylating agent we have found that acetyl migration can be suppressed and secondary cellulose acetates with up to 90% of the free hydroxyl groups in the primary positions prepared.

The general method was similar to that used by Malm *et al.* We prepared a starting compound containing 0·70 primary hydroxyl group per glucose unit by hydrolysing a textile-type cellulose acetate. This was tritylated and then reacetylated. Removing the trityl groups with hydrogen bromide at 0° gave a cellulose acetate of D.S. ~2·3. When higher temperatures were used for detritylation lower percentages of the free hydroxyl groups were in the primary position. The same was the case when water was present in the reaction medium, irrespective of the temperature of detritylation. Above 20° there was evidence of acetylation, during detritylation, from the acetic acid used as solvent and of degradation of the molecular chains.

For products containing less than 30% of the free hydroxyl groups in the primary positions it was found more convenient to acetylate a suitably hydrolysed starting compound directly up to D.S. ~2·3. In a slow, uncatalysed reaction with acetic anhydride at room temperature acetylation was predominantly on the primary hydroxyl groups and yielded products at D.S. ~2·3 with as little as 4% of the free hydroxyl groups in the primary positions. By varying the extent of initial hydrolysis and the conditions of reacetylation products were prepared covering the range 4—30% of free primary hydroxyl. Similarly preparations have been described by Malm *et al.*[2]

The use of hydrogen bromide extends the range of free-hydroxyl distributions which have been reported for secondary cellulose acetates and yields products with interesting solubility characteristics. Some properties of secondary cellulose acetates prepared in this

[1] Malm, Tanghe, and Laird, *J. Amer. Chem. Soc.*, 1948, **70**, 2740.
[2] Malm. Tanghe, Laird, and Smith, *J. Amer. Chem. Soc.*, 1954, **75**, 80.

way are given in the Table. The free-energy parameter, μ,[3] for the interaction of polymer and solvent, which previous work [4] has shown can be used to define the solubility of

Method of prep.	D.S.	Total OH	Primary OH	Primary OH (%)	$\overline{DP}_v$	$\overline{DP}_n$	μ (25°) $COMe_2$	μ (25°) CH_2Cl_2
HBr fission	2·33	0·67	0·58	87	170	145	0·29	0·66
	2·35	0·65	0·47	72	134	115	0·40	0·68
	2·35	0·65	0·25	38	124	110	0·42	0·62
Reactyln.	2·33	0·67	0·12	18	178	152	0·52	0·55
	2·33	0·67	0·09	13	167	143	0·54	0·53
	2·33	0·67	0·03	4	144	130	0·61	0·42
Starting material	2·33	0·67	0·32	48	192	162	0·41	0·63

From the nature of the theoretical derivation, μ would be expected to be nearly independent of molecular weight and concentration for a given solvent–polymer system. For acetone, μ was constant within $\pm 0{\cdot}01$ for five secondary cellulose acetate of D.S. ~2·3 and 40% primary hydroxyl over a $\overline{DP}_n$ range 100—158, suggesting that the variations obtained are indeed related to the hydroxyl distribution.

Infrared absorption at 2·5—15 μ by films cast from each product gave identical curves except for a slight change in the C–H stretching frequencies at 3·40 and 3·48 μ.

cellulose derivatives, varied with the free-hydroxyl distribution. For solutions in acetone it was lower the higher the amount of primary hydroxyl; the reverse held for methylene chloride.

Experimental.—Secondary cellulose acetate of D.S. ~2·3 in which 87% of the free hydroxyl groups were in the primary positions was prepared as follows:

Commercial textile-type cellulose acetate (D.S. 2·33, $\overline{DP}_v$ 192, $\overline{DP}_n$ 162) (100 g.) in which 48% of the free hydroxyl groups were in the primary positions was dissolved in glacial acetic acid (1 l.), and water (200 ml.) containing 36% hydrochloric acid (1·8 g.) was stirred in. The solution was left at 20° in a sealed jar until a sample isolated by precipitation in distilled water showed a primary hydroxyl content of 0·70 mol. per glucose unit, as estimated by the extent of tritylation under conditions employed by Malm *et al.*[5] Hydrolysis was complete in 460 hr. Then the solution was poured into distilled water (8 l.), and the precipitated product filtered off and washed acid-free. It was then dried in air at 60°. The product consisted of hard, horny particles which were ground in a micro-pulveriser to pass 20 mesh. 50 grams of this material (50 g.) were dissolved in anhydrous pyridine [containing $<0{\cdot}01\%$ of water (Karl Fischer)] (250 ml.) at 70° in a sealed flask and then shaken. Triphenylmethyl chloride (60 g.) was added and dissolved by further shaking. The solution was kept at 70° for 24 hr. and the product isolated by dilution with acetone (400 ml.) and pouring the whole slowly into methanol (2 l.) with stirring. The precipitate was collected, washed free from triphenylmethyl chloride with methanol, and dried *in vacuo* over silica gel.

Analysis by sulphuric acid digestion [6] showed 0·69 trityl group per glucose unit.

The tritylated product (10 g.) was dissolved in anhydrous pyridine (50 ml.), and acetic anhydride (20 ml.) was added. The solution was left for 10 days at 25° in a sealed flask, and the product was then isolated by dilution with acetone and pouring into methanol as above. After the product had been washed free from acetic acid and acetic anhydride and dried *in vacuo* over silica gel analysis showed 0·69 trityl group and 2·30 acetyl groups per glucose unit.

The reactylated material (10 g.) was dissolved in anhydrous acetic acid (distilled over chromic oxide) (100 ml.) and stirred at 0°. A gel was formed but was broken up by the stirring. Anhydrous acetic acid (10 ml.), previously saturated with hydrogen bromide at 0°, was added and stirring continued. Within 5 min. the gel had liquefied and triphenylmethyl bromide began to separate. After 5 minutes' stirring the mixture was poured into methanol (2 l.). The precipitate was separated, washed free from bromide and acetic acid, and dried as above. Analysis gave: total OH 0·67, 0·66 group per glucose unit (D.S. 2·33); primary OH 0·58, 0·59 group per glucose unit; Ac 38·7, 38·6%; $\overline{DP}_v$ 170; $\overline{DP}_n$ 145.

[3] Huggins, *Ann. N.Y. Acad. Sci.*, 1942, **45**, 1; Flory, *J. Chem. Phys.*, 1942, **9**, 660; 1942, **10**, 51.
[4] Moore, *Chem. Age*, 1956, 255.
[5] Malm, Tanghe, and Laird, *Analyt. Chem.*, 1954, **26**, 188.
[6] Hearon, Hiatt, and Fordyce, *J. Amer. Chem. Soc.*, 1941, **63**, 3156.

Analyses. Primary hydroxyl was estimated by the method of Malm *et al.*,[5,7] with sulphuric acid digestion [6] for the determination of triphenylmethyl. The method of Gardner and Purves [8] (toluene-*p*-sulphonyl chloride followed by iodination) was also used, with similar results.

The total hydroxyl content was estimated by isolating and weighing the carbanilate,[5] and the acetyl content by saponification.[9]

$\overline{DP}_v$ was evaluated from the intrinsic viscosity determined at the triacetate level by acetylation in 1 : 1 acetic anhydride–pyridine for 10 days at 25°. This procedure caused no degradation and the intrinsic viscosity was determined directly in the acetylation solvents. The relation $1{\cdot}02[\eta] = 8{\cdot}97 \times 10^{-5}[288\overline{DP}_v \times 0{\cdot}9012]^{0{\cdot}9}$ was used to derive $\overline{DP}_v$ from the intrinsic viscosity $[\eta]$. This relation held closely over a wide range. It has given values for $\overline{DP}_v$ which agree closely with those obtained by the relation derived by Phillip and Bjork [10] for cellulose acetates of D.S. ~2·3 and 40% primary hydroxyl content in acetone and has been confirmed by sedimentation studies.

$\overline{DP}_n$ was evaluated from the osmotic pressure in acetone or methylene chloride extrapolated to zero concentration.

The solvent–polymer free-energy parameter was determined from the slope of osmotic pressure–concentration plots. Where two-phase systems were obtained ($\mu > 0{\cdot}55$) the concentration and volume of the two phases were measured and μ obtained by equating Huggins's expression [11] for the activity of the polymer in each phase. In two samples of very low solubility the swelling of films was measured to obtain a value for μ.

C.S.R. Chemicals Pty. Ltd., 1 Mary Street,
Rhodes, Sydney, Australia. [*Received, August 8th*, 1960.]

[7] Malm, Tanghe, and Laird, *J. Amer. Chem. Soc.*, 1950, **72**, 2674.
[8] Gardner and Purves, *J. Amer. Chem. Soc.*, 1942, **64**, 1939.
[9] Malm, Genung, Williams, and Pile, *Ind. Eng. Chem., Analyt.*, 1944, **16**, 501.
[10] Phillip and Bjork, *J. Polymer Sci.*, 1951, **61**, 549.
[11] Huggins, "Cellulose and Cellulose Derivatives," Interscience Publ. Inc., New York, 1955, Part III, pp. 1115, 1200.

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159. 8-*Hydroxyquinoline Complexes of the Dibutyl- and Diphenyltin Radicals.*

By D. Blake, G. E. Coates, and J. M. Tate.

Most compounds containing di-n-butyltin and diphenyltin groups are relatively low melting and too soluble in organic solvents for easy purification. The 8-hydroxyquinoline derivative, $R_2Sn(C_9H_6NO)_2$, is in both cases easy to prepare and to purify, and serves as a convenient compound for characterization.

Experimental.—8-Hydroxyquinoline (2 mol.) in ethanol was added to di-n-butyltin dichloride (1 mol.) in ethanol. The dioxine *derivative* is precipitated on addition of sodium acetate in aqueous ethanol, followed by a little aqueous ammonia. Crystallization from ethanol or light petroleum (b. p. 80—100°) gives yellow plates, m. p. 154·5—155·5° (Found: C, 59·6; H, 5·8. $C_{26}H_{30}N_2O_2Sn$ requires C, 59·9; H, 5·8%).

Diphenyltin di-(8-hydroxyquinolinate), similarly prepared from diphenyltin dibromide, forms yellow plates, m. p. 231—233° (from ethanol) (Found: C, 64·3; H, 3·9. $C_{30}H_{22}N_2O_2Sn$ requires C, 64·3; H, 3·9%).

Dichlorodi-n-butyl-(2,2′-bipyridyl)tin is immediately precipitated when 2,2′-bipyridyl (1 mol.) in ethanol is added to di-n-butyltin dichloride (1 mol.) in the same solvent, and crystallizes from ethanol or light petroleum (b. p. 80—100°) as colourless needles, m. p. 179·5—180° (Found: C, 46·9; H, 5·9. $C_{18}H_{26}Cl_2N_2Sn$ requires C, 47·0; H, 5·7%).

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South Road, Durham. [*Received, September 1st*, 1960.]

160. *Further Studies on the Preparation of Symmetrical Pinacols by Cathodic Reduction.*

By M. J. Allen, M. Cohen, W. G. Pierson, and (Miss) J. A. Siragusa.

We here report the electrochemical preparation of some new pinacols in yields which, though often poor owing to the instability of the starting material in the electrolysis medium, are yet better than can be obtained by the usual chemical methods. Although 4-aminoacetophenone forms its pinacol [1] quite readily, 3-aminoacetophenone apparently decomposes too rapidly in the medium. However, electrolysis of 3-acetamidoacetophenone does give the corresponding pinacol. It was possible to obtain some pinacol from the rather unstable 3-amino-4-methoxyacetophenone, but cathodic reduction of the acetylated ketone gave a better yield.

Experimental.—The electrolytic cells as well as the Redoxotrol used for the controlled potential reductions have been described previously.[2] A porous membrane separated the mercury cathode from the platinum anode. The reference potentials used were obtained from voltametric curves obtained under conditions identical with those used preparatively. The experimental data are given in the Table.

3-Amino-4-methoxyacetophenone and 3-acetyl-6-methylpyridine were obtained from the Aldrich Chemical Company, Milwaukee, Wisc., U.S.A. 3-Acetamidoacetophenone,[3] 3-acetamido-4-methoxyacetophenone,[4] ω-dimethylaminoethyl-4-methoxyacetophenone,[5] and 3-propionylpyridine [6] were prepared by published methods. The 3-acetyl-6-dimethylaminopyridine, prepared by reaction of 3-acetyl-6-chloropyridine [7] with dimethylamine, was kindly supplied by Dr. G. Walker of our laboratories.

Isolation of pinacols. (*a*) The catholyte was evaporated to a small volume under reduced pressure, then refrigerated, and the gum which separated was washed with water, dissolved in a minimum quantity of acetone, filtered, and treated with a large excess of ether. The precipitate was collected, triturated with ether, and recrystallized from acetone, giving 2,3-*di*-m-*acetamidophenylbutane*-2,3-*diol* (1·01 g.), m. p. 265·5—267·5° (decomp.) (Found: C, 67·1; H, 6·95; N, 7·7. $C_{20}H_{24}N_2O_4$ requires C, 67·4; H, 6·8; N, 7·9%).

(*b*) The filtered catholyte was made basic with a saturated solution of potassium carbonate, and the resulting yellow solid separated by decantation and extracted a number of times with methylene chloride. The extracts were dried (Na_2SO_4) and evaporated under reduced pressure. The residue was triturated with cold anhydrous ethanol, and the solid which was formed crystallized from 50% ethanol (charcoal). Recrystallization from ethanol–ether yielded the 2,3-*di*-(3-*amino*-4-*methoxyphenyl*)*butane*-2,3-*diol* (0·27 g.), m. p. 201—202° (Found: C, 64·7; H, 7·4; N, 8·2. $C_{18}H_{24}N_2O_4$ requires C, 65·0; H, 7·3; N, 8·4%).

(*c*) The residue obtained on evaporation of the catholyte was taken up in methylene chloride. The solution was dried (Na_2SO_4), filtered, and diluted with an excess of pentane. The precipitate crystallized from methylene chloride–pentane and then from ethyl acetate to yield 2,3-*di*-(3-*acetamido*-4-*methoxyphenyl*)*butane*-2,3-*diol* (1·02 g.), m. p. 176—178° (Found: C, 63·6; H, 7·0; N, 6·5. $C_{22}H_{28}N_2O_6$ requires C, 63·4; H, 6·8; N, 6·7%).

(*d*) The catholyte was evaporated under reduced pressure below 40° and the yellow oil obtained dissolved in isopropyl alcohol (200 ml.). This solution upon dilution with an excess of ether gave a gummy yellow solid which was washed with ether, dried, and then dissolved in water. This solution was made basic and the precipitate extracted with ether. After evaporation of the dried ether extracts the residue was triturated with pentane to yield a white powder which, on crystallization from ether, gave 1,6-*bisdimethylamino*-3,4-*di*-p-*methoxyphenylhexane*-3,4-*diol* (13·4 g.), m. p. 161° (Found: C, 69·5; H, 8·7; N, 6·85. $C_{24}H_{36}N_2O_4$ requires C, 69·2; H, 8·7; N, 6·7%).

[1] Allen and Corwin, *J. Amer. Chem. Soc.*, 1950, **72**, 114.
[2] Allen, "Organic Electrode Processes," Chapman and Hall, London, 1958, pp. 24—28, 33—39; *Canad. J. Chem.*, 1959, **37**, 257.
[3] Rupe, Braun, and von Zembruski, *Ber.*, 1901, **34**, 3523.
[4] Bogert and Curtin, *J. Amer. Chem. Soc.*, 1923, **45**, 2164.
[5] Mannich and Lammering, *Ber.*, 1922, **55**, 3518.
[6] Engler, *Ber.*, 1891, **24**, 2539.
[7] Räth and Schiffmann, *Annalen*, 1931, **487**, 127.

(*e*) Water (40 ml.) was added to the catholyte and the basicity adjusted to pH 8 with dilute hydrochloric acid. The mixture was saturated with sodium chloride and extracted with methylene chloride, and the extracts were dried and evaporated under reduced pressure. The residue, on trituration with ethyl acetate, gave 3,4-*di*-3′-*pyridylhexane*-3,4-*diol* (1·2 g.), m. p. 188—189° (from aqueous methanol) (Found: C, 70·3; H, 7·4; N, 10·6. $C_{16}H_{20}N_2O_2$ requires C, 70·55; H, 7·4; N, 10·3%).

(*f*) The yellow solid formed on evaporation of the catholyte under reduced pressure was triturated with a small quantity of 5% ethanol and left at room temperature overnight. The precipitate was collected and recrystallized from aqueous ethanol, giving 2,3-*bis*-(6-*dimethylamino*-3-*pyridyl*)*butane*-2,3-*diol* (1·73 g.), m. p. 247—248° (Found: C, 65·6; H, 8·0; N, 16·9. $C_{18}H_{26}N_4O_2$ requires C, 65·4; H, 7·9; N, 16·95%).

Catholyte	(*a*) 3-NHAc·C_6H_4·COMe (15 g.) EtOH (90 ml.) H_2O (33·6 ml.) KOAc (40·5 g.)	(*b*) 3-NH_2-4-MeO·C_6H_4·COMe (3·9 g.) Conc. HCl (3·9 ml.) H_2O (46·1 ml.)
Anolyte	40% K_2CO_3	Conc. HCl (3·9 ml.), H_2O (46·1 ml.)
Cathode area (cm.²)	52	20·5
Ref. pot. *vs.* S.C.E. (v)	−1·60	−1·10
Electrolysis temp.	81·5° (b. p.)	20—25°
Initial amperage	5·8	3·5
Final amperage	0·5	0·25
Initial applied voltage	13·5	8·0
Final applied voltage	3·5	3·9
Electrolysis time (min.) to current plateau	73	32
Coulombs passed	9212 (112%)	2084 (91·4%)
Yield (%)	6·7	6·9

Catholyte	(*c*) 3-NHAc-4-MeO·C_6H_4·COMe (3·0 g.) EtOH (25 ml.) 2N-KOH (25 ml.)	(*d*) 4-MeO·C_6H_4·CO·CH_2·CH_2·NMe_2,HCl (13·8 g.) Conc. HCl (23 ml.) H_2O (897 ml.)
Anolyte	N-KOH	Conc. HCl (2 ml.), H_2O (78 ml.)
Cathode area (cm.²)	20·5	111·3
Ref. pot. *vs.* S.C.E. (v)	−2·0	−1·36
Electrolysis temp.	30°	27—29°
Initial amperage	4·1	7·4
Final amperage	0·04	0·9
Initial applied voltage	17·0	15·0
Final applied voltage	2·5	5·1
Electrolysis time (min.) to current plateau	61	270
Coulombs passed	1522 (108%)	60,190 (110%)
Yield (%)	33·3	11·4

Catholyte	(*e*) 3-C_5H_4N·COEt (6 g.) EtOH (7·5 ml.) 1·5N-KOH (22·5 ml.)	(*f*) 6-Me_2N·C_5H_3N·COEt-3 (6 g.) EtOH (30 ml.) 2N-KOH (30 ml.)	(*g*) 6-Me·C_5H_3N·COMe-3 (3·9 g.) Conc. HCl (3·9 ml.) H_2O (46·1 ml.)
Anolyte	1·5N-KOH–EtOH (3 : 1)	40% K_2CO_3	Conc. HCl (3·9 ml.), H_2O (46·1 ml.)
Cathode area (cm.²)	16	20·5	20·5
Ref. pot. *vs.* S.C.E. (v)	−1·60	−1·90	−1·10
Electrolysis temp.	40°	25°	25°
Initial amperage	5·5	6·0	3·5
Final amperage	0·55	0·15	0·25
Initial applied voltage	19·0	41·7	8·0
Final applied voltage	5·0	3·8	3·9
Electrolysis time (min.) to current plateau	31	88	32
Coulombs passed	3828 (89·3%)	4196 (119·3%)	2084 (91·4%)
Yield (%)	19·8	28·8	63·8

(*g*) The crystalline precipitate formed during the reaction was filtered off from the catholyte

after refrigeration. On being washed with ethanol–ethyl acetate (1 : 1) and recrystallized from ethanol it gave 2,3-*di*-(6-*methyl*-3-*pyridyl*)*butane*-2,3-*diol* (4·37 g.), m. p. 218—219° (Found: C, 70·2; H, 7·4; N, 9·9. $C_{16}H_{20}N_2O_2$ requires C, 70·55; H, 7·4; N, 10·3%).

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[*Received, September 5th*, 1960.]

161. *Quaternary Derivatives of 2,2′-Pyridil Dioxime and of 2,2′-Bipyridyls.*

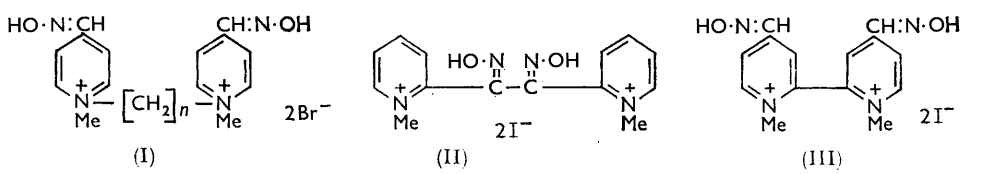
By MARY PITMAN and P. W. SADLER.

4-MONOXIMES and 4,4′-dioximes of polymethylene-1,1′-di(pyridinium bromide) (I; $n = 1$—5) are potent reactivators of diethyl and di-*O*-isopropylphosphorylacetocholinesterases.[1,2] Bonding of the quaternary ammonium groups to two sites of the enzyme surface has been postulated to explain the high activity,[2] and the finding that the trimethylene derivative (I; $n = 3$) has the highest activity indicates that these two points of attachment are separated by a distance not exceeding 5 Å. To obtain further information concerning the intersite distance, potential reactivators with more rigid structures were investigated, namely, compounds of type (II) and (III) containing C_4 and C_2 links respectively between the nitrogen atoms.

A dioxime of 2,2′-pyridil has been described,[3] but this seems to have been a mixture as two dioximes and a monoxime were obtained by us on reaction of hydroxylamine with 2,2′-pyridil. The three oximes were quaternized by the action of methyl iodide in nitrobenzene.

The action of freshly sublimed selenium dioxide on 4,4′-dimethyl-2,2′-bipyridyl under various conditions gave a mixture of products including the 4,4′-dicarboxy-, 4-carboxy-4′-methyl, and 4-carboxy-4′-formyl derivative in addition to the dialdehyde which was obtained only in small yield. Although 2,2′-bipyridyl[4] and 4,4′-dimethyl-2,2′-bipyridyl were quaternized by the action of methyl iodide in a sealed tube, the dimethiodide (III) was not obtained from the dioxime.

The quaternary dioximes (II) have reactivating properties similar to that of pyridine-2-aldoxime methiodide.



(I) (II) (III)

Experimental.—*2,2′-Pyridil oximes.* 2,2′-Pyridil (0·3 mole) was heated with hydroxylamine (0·6 mole) in ethanol (1 l.) containing sodium (1·5 g.) for 1 hr. The reaction mixture was filtered and reduced to 200 c.c. before the addition of hot water (300 c.c.), which precipitated material (41 g.), m. p. 228°, containing three components. A *2,2′-pyridil dioxime* (4·8%), m. p. 246°, was sparingly soluble in hot ethanol and was recrystallized to constant m. p. from 50% aqueous ethanol (Found: C, 59·4; H, 4·2; N, 23·3. $C_{12}H_{10}N_4O_2$ requires C, 59·5; H, 4·1; N, 23·1%). A *2,2′-pyridil dioxime* (28%), m. p. 235°, was obtained pure after several recrystallizations from ethanol (Found: C, 59·5; H, 4·1; N, 22·8%). Concentration of these liquors

[1] Hobbiger, O'Sullivan, and Sadler, *Nature*, 1958, **182**, 1498; Hobbiger and Sadler, *Nature*, 1958, **182**, 1672; Hobbiger and Sadler, *Brit. J. Pharmacol.*, 1959, **14**, 192.
[2] Hobbiger, Pitman, and Sadler, *Biochem. J.*, 1960, **75**, 363.
[3] Mathes, Sauermilch, and Klein, *Chem. Ber.*, 1951, **84**, 452; Blau, *Monatsh.*, 1889, **10**, 382.
[4] Case, *J. Amer. Chem. Soc.*, 1946, **68**, 2527.

and the addition of water gave a *monoxime* (1·4%), m. p. 207° (from ethanol) (Found: C, 63·2; H, 4·1; N, 18·5. $C_{12}H_9N_3O_2$ requires C, 63·4; H, 4·0; N, 18·5%). Mathes *et al.*[3] described a dioxime, m. p. 215°; no analysis was given.

The dioxime of m. p. 235° (5 g.) was heated in nitrobenzene (100 c.c.) with a two-fold excess of methyl iodide under reflux for 18 hr. After cooling, the nitrobenzene was decanted from an oil. Several crystallisations from methanol gave the *dimethiodide* as yellow needles, m. p. 259° (Found: C, 32·0; H, 3·4; N, 10·5; I, 48·2. $C_{14}H_{16}I_2N_4O_2$ requires C, 31·9; H, 3·1; N, 10·7; I, 48·3%). The dioxime of m. p. 246° similarly gave a *dimethiodide*, m. p. 274° (Found: C, 32·1; H, 3·1; I, 49·0%). The *monoxime dimethiodide* had m. p. 193° (Found: C, 33·5; H, 2·8; I, 49·6. $C_{14}H_{15}I_2N_3O_2$ requires C, 32·9; H, 2·9; I, 49·7%).

4,4′-Dimethyl-2,2′-bipyridyl. This base was obtained as plates (from benzene), m. p. 171°, by Case's method.[4] In the reaction of 2-bromo-4-methylpyridine with copper powder, concentrated hydrochloric acid was used for extraction of the mixture to achieve the reported yield (33%).

Oxidation of 4,4′-dimethyl-2,2′-bipyridyl. Reactions were carried out on 0·02 molar scale. 4,4′-Dimethyl-2,2′-bipyridyl, intimately mixed with freshly sublimed selenium dioxide, was gently heated. A vigorous reaction ensued, the temperature rising to 130°. The mixture was kept at 120° for ¼ hr., then extracted with 17% hydrochloric acid. No ketonic compound was isolated from the neutralised extract. *4′-Methyl-2,2′-bipyridyl-4-carboxylic acid* was obtained in a similar experiment in which the mixture was extracted with boiling isopentyl acetate (Found: C, 67·6; H, 4·8; N, 13·1. $C_{12}H_{10}N_2O_2$ requires C, 67·3; H, 4·7; N, 13·1%). The same product was obtained when the reactants were heated under reflux in glacial acetic acid for ½ hr.; heating for longer periods produced 2,2′-bipyridyl-4,4′-dicarboxylic acid. No reaction occurred when the reactants were heated under reflux in ethyl acetate for ½ hr. but when isopentyl acetate was used, 200 mg. of the *4,4′-dialdehyde* were obtained (Found: C, 67·8; H, 4·1; N, 13·5. $C_{12}H_8N_2O_2$ requires C, 67·9; H, 3·8; N, 13·2%) together with unchanged starting material; the dialdehyde gave a *dioxime*, m. p. 277° (Found: C, 59·8; H, 4·3; N, 23·3. $C_{12}H_{10}N_4O_2$ requires C, 59·5; H, 4·1; N, 23·1%). Heating under reflux for longer periods gave *4′-formyl-2,2′-bipyridyl-4-carboxylic acid* as the major product (Found: C, 63·2; H, 3·5; N, 11·7. $C_{12}H_8N_2O_3$ requires C, 63·2; H, 3·5; N, 12·3%) [*2,4-dinitrophenylhydrazone* (Found: C, 52·9; H, 2·9; N, 20·8. $C_{18}H_{13}N_6O_6$ requires C, 52·9; H, 2·7; N, 20·6%).

1,1′,4,4′-Tetramethyl-2,2′-bipyridylium di-iodide. 4,4′-Dimethyl-2,2′-bipyridyl (1 g.) was heated in methanol (5 c.c.) with methyl iodide (2 c.c.) at 100° for 10 hr. in a sealed tube. From methanol the *dimethiodide* formed lemon-yellow crystals, m. p. 279° (Found: C, 36·1; H, 3·9; I, 53·9. $C_{14}H_{18}I_2N_2$ requires C, 35·9; H, 3·9; I, 54·3%).

The three acids and the aldehyde did not melt below 320°.

The authors thank the D.S.I.R. for a special research grant.

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162. *A Simple Route to 4,5-Diamino-2-hydroxypyrimidine.*

By ABRAHAM KALMUS and FELIX BERGMANN.

4,5-DIAMINO-2-HYDROXYPYRIMIDINE is the key compound for the synthesis of 2-hydroxypurine and 8-substituted derivatives. Until now, it has been prepared by reduction of 5-nitrocytosine.[1] The recent finding that 4,5-diaminouracil is converted by phosphorus pentasulphide selectively into the 6-thione,[2] opened a new approach by catalytic desulphuration. This reaction proceeded with satisfactory yield in N-sodium hydroxide. 4,5-Diamino-2-hydroxypyrimidine can be isolated conveniently as the sulphate.

Previous experience has shown that desulphuration of a methylthio-derivative requires

[1] Johns, *Amer. Chem. J.*, 1911, **45**, 82.
[2] Levin, Kalmus, and Bergmann, *J. Org. Chem.*, 1960, **25**, 1752.

less drastic conditions than that of the parent thione and thus results in higher yields.[3] The 6-methylthio-pyrimidine was very sensitive to alkali, and reaction with Raney nickel was carried out in an aqueous suspension. The yield of 4,5-diamino-2-hydroxypyrimidine was slightly higher than that obtained by direct desulphuration of the 6-thione. However, the overall yield of diaminohydroxypyrimidine from diaminouracil was greater by the latter route.

Condensation of 4,5-diamino-2-hydroxypyrimidine sulphate with urea leads quantitatively to 2,8-dihydroxypurine. Similar high yields have been obtained by Johns [1] in the cyclisation of the diaminohydroxypyrimidine to 2-hydroxypurine.

Experimental.—4,5-*Diamino-2-hydroxypyrimidine sulphate.* A solution of 4,5-diamino-2-hydroxy-6-mercaptopyrimidine sulphate [2] (2·2 g., 0·01 mole) in N-sodium hydroxide (20 ml., 2 equiv.) was refluxed with vigorous stirring for 2 hr., in the presence of Raney nickel (2 g.). The catalyst was removed and the filtrate acidified with 10% sulphuric acid, producing 4,5-diamino-2-hydroxypyrimidine sulphate monohydrate [1] (1·65 g., 67%). Recrystallization from 10% sulphuric acid gave white prisms, decomposing above 300°.

4,5-*Diamino-2-hydroxy-6-methylthiopyrimidine.* A mixture of the 6-mercaptopyrimidine sulphate (2·2 g., 0·01 mole), 0·5N-sodium hydroxide (40 ml.), and methyl iodide (2 ml.) was stirred at room temperature for 1 hr. The precipitate crystallised from water in yellowish needles (1·3 g., 74%) which decomposed at about 260° (Found: C, 35·0; H, 4·5. Calc. for $C_5H_8N_4OS$: C, 34·9; H, 4·65%): $\lambda_{max.}$ at pH 2·5, 320—321 mμ; at pH 8·0, 312—313 mμ.

For desulphuration, a suspension of 4,5-diamino-2-hydroxy-6-methylthiopyrimidine (1·7 g.; 0·01 mole) and Raney nickel (2 g.) in 100 ml. of water was stirred at 80—85° for 1 hr. The filtrate was concentrated *in vacuo*. The crystals (0·95 g.; 75%) deposited overnight were recrystallised from 10% sulphuric acid, producing white prisms of 4,5-diamino-2-hydroxypyrimidine sulphate monohydrate (see above).

2,8-*Dihydroxypurine.* An intimate mixture of the diaminohydroxypyrimidine (0·24 g.) and urea (0·2 g.) was heated to 195° during 20 min. The cake was dissolved in ammonia solution (10%; 6 ml.), the solution decolorised with charcoal, and the filtrate acidified with glacial acetic acid. Short needles (0·15 g., 100%), decomposing above 300°, were obtained; $\lambda_{max.}$ at pH 8·0, 263 and 306 mμ.[4] The compound was chromatographically pure.

This study was supported by the United States National Institutes of Health.

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[3] Kalmus and Bergmann, *J.*, 1960, 3679.
[4] Mason, *J.*, 1954, 2071.

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163. *Deamination of Cyclohexylamine by* [^{18}O]*Nitrous Acid.*

By D. L. Boutle and C. A. Bunton.

Streitweiser and Schaeffer [1] have shown that the deamination of optically active [2-^{2}H]cyclohexylamine proceeds with retention of configuration. This observation suggests that the life of the intermediate carbonium ion is less than that required for interconversion of the cyclohexane ring.[2] Another possible reaction path, which would give retention of configuration, is an S_Ni decomposition of an intermediate such as the hypothetical diazo-hydroxide (I) or its conjugate acid.

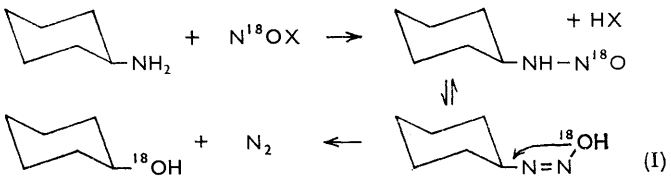
This reaction path has been excluded, for deamination in water, by the use of [^{18}O]-nitrous acid. The difficulty in this type of experiment is that nitrous acid readily exchanges its oxygen with water. Provided that deamination is under conditions such that the predominant exchange path is the slow formation, and subsequent hydration, of dinitrogen

[1] Streitweiser and Schaeffer, *J. Amer. Chem. Soc.*, 1959, **81**, 4275.
[2] Dauben, Tweit, and Hannerkautz, *J. Amer. Chem. Soc.*, 1954, **76**, 4420.

trioxide, it is possible for attack of the amine on the latter to be faster than that of water: [3]

$2HNO_2 \rightleftharpoons H_2O + N_2O_3 \xrightarrow{R\cdot NH_2}$ Products. This experiment has already been done with aniline, which suppressed the exchange of nitrous acid by trapping dinitrogen trioxide as fast as it was formed.[3]

We have now done a similar experiment with cyclohexylamine and find that it is possible partially to suppress the exchange of the nitrous acid. The cyclohexanol isolated



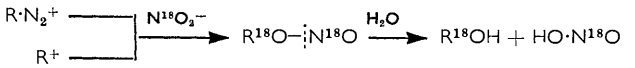
(I)

from this deamination had more than 90% of its oxygen derived from the water, and there was only 30% of exchange of oxygen between nitrous acid and water. Therefore the absence of oxygen derived from the nitrous acid was not an artefact of an exchange with water.

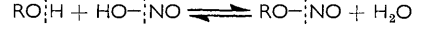
Isotopic abundances of cyclohexanol.

Isotopic abundance (atom % excess): $NaNO_2$ 0·97, 0·86; ROH 0·08, 0·08.

The small amount of tracer in the cyclohexanol (see above) could have come from the reaction between the carbonium (or diazonium) ion and the nitrite ion:



This reaction should also exchange an oxygen atom between water and nitrous acid; another route for this exchange is: [4]



The deamination of [2-^{2}H]cyclohexylamine was in aqueous acetic acid,[1] whereas we used water as solvent. This was because nitrosyl acetate reacts more readily with water than with amines, and if it were present it would be difficult to suppress the oxygen exchange of the nitrous acid.[3,5] However it is unlikely that such a change of solvent could affect the whole nature of the deamination.

Experimental.—Cyclohexylamine (10 g.) was dissolved in isotopically normal water (60 c.c.) containing sodium [^{18}O]nitrite [6] (20 g.). (For the control test on the exchange, 7 g. of sodium nitrite were used.) 2M-Sulphuric acid was added dropwise with vigorous stirring at *ca.* 25°. The pH was measured with a Cambridge pH meter. The initial value of pH was *ca.* 9, and the rate of addition of acid was regulated so that it never fell below 6. (After the theoretical amount of sulphuric acid had been added the pH fell sharply.) The reaction required several hours for completion. The solution was then warmed to 40° with excess of alkali to hydrolyse any cyclohexyl nitrite present; [4] this heating was omitted from the control experiment on the exchange of nitrous acid.

The cyclohexanol was isolated by Streitweiser and Schaeffer's method [1] (extraction with ether from a solution saturated with sodium chloride). The crude cyclohexanol was purified by gas–liquid chromatography on a Silicone oil–Celite column. The isotopic abundance of the cyclohexanol was determined by equilibration with carbon dioxide.[7] For the control test

[3] Bunton and Masui, *J.*, 1960, 304.
[4] Allen, *J.*, 1954, 1968.
[5] Anbar and Taube, *J. Amer. Chem. Soc.*, 1955, **77**, 2993.
[6] Bunton, Llewellyn, and Stedman, *J.*, 1959, 568.
[7] Dahn, Moll, and Menassé, *Helv. Chim. Acta*, 1959, **42**, 1224.

on the exchange of nitrous acid, in the presence of cyclohexylamine, the isotopic abundance of the sodium nitrite was determined by Anbar and Taube's method.[5]

We thank Professor C. W. Shoppee, F.R.S., for suggestions.

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[*Received, September 5th,* 1960.]

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164. *An Enzymic Resolution of Serine.*

By LEO BENOITON.

IN the case of serine, the Greenstein enzymic procedure [1] for the resolution of amino-acids is not entirely satisfactory because the required substrate, *N*-chloroacetylserine, cannot be obtained in good yield. The need for optically active serine in this laboratory has induced a search for a more satisfactory preparation of this derivative, or, alternatively, for some other substrate.

N-Chloroacetylserine was prepared directly by the activated ester method [2] using *p*-nitrophenyl chloroacetate, and indirectly, by an *O* ⟶ *N*-acyl shift, from *O*-chloroacetylserine in basic solution, but neither method gave the desired yield. The *O*-chloroacetylserine was obtained by reverse esterification of serine by molten chloroacetic acid saturated with hydrogen chloride.

A satisfactory resolution was achieved by using the acetyl derivative as substrate.[3] *N*-Acetyl-DL-serine was prepared from DL-serine by the *O* ⟶ *N*-acyl shift [4] applied to *O*-acetyl-DL-serine [5] and was resolved without isolation of any of these intermediates, to give L- and D-serine in yields of 70 and 60% respectively. The overall procedure was such that it is readily applicable to both small and large quantities.

Another interesting application of the *O* ⟶ *N*-acyl shift was the preparation of *N*-glycylserine from *O*-chloroacetylserine hydrochloride in methanolic ammonia.

Experimental.—*N-Chloroacetyl-*DL*-serine.* (*a*) Activated ester method. Chloroacetyl chloride (2·25 g.) was added to the sodium salt of *p*-nitrophenol (3·2 g.) in ethyl acetate, and the suspension was warmed until the orange colour had disappeared (5 min.). The mixture was cooled and filtered, the filtrate evaporated, and the residue crystallised from benzene, to give *p*-nitrophenyl chloroacetate (3·3 g., 70%), m. p. 95° (lit.,[6] 94°). This ester (1·57 g.) in ethyl acetate (15 ml.) was added to DL-serine (0·5 g.) and sodium hydrogen carbonate (0·63 g.) in water in an open vessel, and the mixture was stirred vigorously for 18 hr. The precipitate of *p*-nitrophenol was filtered off, and the filtrate washed with ethyl acetate, acidified, and saturated with sodium chloride and finally exhaustively extracted with ethyl acetate. The ethyl acetate was dried, the solvent removed under a vacuum, and the residue triturated with light petroleum; filtration and recrystallisation from ethyl acetate, gave the *N*-chloroacetyl derivative (0·4 g., 45%), m. p. 123° (lit.,[7] m. p. 122—123°).

(*b*) By *O* ⟶ *N*-acyl shift. DL-Serine (8·4 g.) was dissolved in molten chloroacetic acid (50 g.), and a slow stream of hydrogen chloride was passed through the solution, kept at 65—70°, for 8 hr. The solution was allowed to cool and ether (150 ml.) was added gradually as crystallisation occurred. The solid was filtered off, washed with ether, and redissolved in hot chloroacetic acid, and the whole operation was then repeated twice. Recrystallisation of the final product from glacial acetic acid gave, after washing with ether, the slightly hygroscopic *O-chloroacetyl-*DL*-serine hydrochloride* (10·5 g., 60%), m. p. 147—148°. A sample for analysis

[1] Greenstein, *Adv. Protein Chem.*, 1954, **9**, 121.
[2] Bodansky, *Acta Chim. Acad. Sci. Hung.*, 1957, **10**, 335.
[3] Akabori, Otani, Marshall, Winitz, and Greenstein, *Arch. Biochem. Biophys.*, 1959, **83**, 1.
[4] Narita, *Biochim. Biophys. Acta*, 1958, **30**, 352.
[5] Sheehan, Goodman, and Hess, *J. Amer. Chem. Soc.*, 1956, **78**, 1367.
[6] Auwers, Baum, and Lorenz, *J. prakt. Chem.*, 1927, **115**, 81.
[7] Fischer and Roesner, *Annalen*, 1910, **375**, 199.

was dried under a vacuum at 78° (Found: C, 27·5; H, 4·2; N, 6·3. $C_5H_9Cl_2NO_5$ requires C, 27·5; H, 4·2; N, 6·4%).

To samples of this *O*-acyl derivative, dissolved in water, were added N-sodium hydroxide, N-ammonia, and triethylamine until the solutions remained basic to Methyl Red. After 2 hr. the solutions were acidified and the *N*-chloroacetyl-DL-serine was isolated by extraction with ethyl acetate as described above. Yields of 30—45% were obtained.

Resolution of DL-*serine.* A suspension of DL-serine (4·2 g.) in anhydrous acetic acid (100 ml.) was saturated with hydrogen chloride at room temperature. Within a few minutes the serine had dissolved, after which the *O*-acetyl derivative began to crystallise. Next day, the precipitate (5·9 g., 80%; containing only a trace of serine) was collected and washed with ether, and the filtrate and washings were evaporated to dryness. The precipitate and residue were recombined (the filtration was found more convenient than evaporation of the reaction mixture) and dissolved in water (40 ml.), and N-ammonia was added until the solution remained basic to litmus. After 30 min. (the $O \longrightarrow N$ shift is practically instantaneous) the solution was placed under a vacuum to remove excess of ammonia, and passed through a column (50 ml. burette) of Amberlite IR-120 (H^+ form) which was subsequently washed with water. That portion of the eluate which was acid to Congo Red was brought to pH 7·5 with ammonia, 30 mg. of acylase I[8] were added, and the solution was kept at 37° for 16 hr. An additional 5 mg. of enzyme were then added and the digestion was allowed to continue a further 8 hr. The digest was brought to pH 5·2 with acetic acid, treated with charcoal, and filtered, the filtrate was concentrated, and ethanol (5 vols.) was added. After several hours' cooling, the L-serine (1·37 g.) was collected. The mother-liquor was freed from ethanol under a vacuum, the remaining solution was passed through the regenerated Amberlite IR-120 column, and the column was eluted first with water and then with N-ammonia. Evaporation of the ammonia eluate gave a second crop (0·25 g.) of the L-isomer. Recrystallisation of the combined products from water–ethanol afforded L-serine (1·47 g., 70%), $[\alpha]_D^{25}$ +14·3° (*c* 2 in N-hydrochloric acid) (lit.,[8] $[\alpha]_D^{25}$ +15·1°) (Found: N, 13·1. Calc. for $C_3H_7NO_3$: N, 13·3%).

The aqueous eluate (acid to Congo Red), which was obtained before the elution with ammonia, was concentrated and then refluxed in 2N-hydrochloric acid for 2 hr. The hydrolysate was evaporated to dryness, the residue taken up in water, the solution brought to pH 5·7 with pyridine, and the amino-acid precipitated with ethanol. Recrystallisation from water–ethanol gave D-serine (1·26 g., 60%), $[\alpha]_D^{25}$ −14·4° (*c* 2 in N-hydrochloric acid) (lit.,[8] $[\alpha]_D^{25}$ −15·0°) (Found: N, 13·1%).

A small amount of DL-serine (4%) was recovered by eluting the resin column with aqueous ammonia after the first resin treatment prior to the digestion.

N-*Glycyl*-DL-*serine.* A solution of *O*-chloroacetyl-DL-serine hydrochloride (0·5 g.) in methanol (25 ml.) was saturated with ammonia and left at 23° for 3 days. The solution was concentrated to a small bulk, then cooled, and the crystals were collected and washed by suspension in methanol. Recrystallisation from water–ethanol gave the dipeptide (0·25 g., 60%) (Found: N, 17·2. Calc. for $C_5H_{10}N_2O_4$: N, 17·3%) which was chromatographically indistinguishable from an authentic sample prepared from *N*-chloroacetyl-DL-serine.[9]

I thank Professor H. N. Rydon for his encouragement and advice, the University of Exeter for the award of an Imperial Chemical Industries Fellowship, and the British Council for a travel grant.

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[8] Birnbaum, Levintow, Kingsley, and Greenstein, *J. Biol. Chem.*, 1952, **194**, 455.
[9] Rao, Birnbaum, Kingsley, and Greenstein, *J. Biol. Chem.*, 1952, **198**, 507.