NOTES.

117. *Chemistry of the Metal Carbonyls. Part XXII.*[1] *Perfluoropropyl- and Perfluoroethyl-(1,2-bisdiphenylphosphinoethane)nickel Iodide.*

By D. W. McBride, S. L. Stafford, and F. G. A. Stone.

It has been shown recently that perfluoroalkyl iodides react with iron pentacarbonyl to form complexes of the type $R_F \cdot Fe(CO)_4 \cdot I$ ($R_F = CF_3$, C_2F_5, or n-C_3F_7).[2] The similarity between this reaction and that between iodine and iron pentacarbonyl to afford $Fe(CO)_4I_2$ has been discussed.[2b] Indeed it has been suggested [2b] that, in metal carbonyl chemistry, perfluoroalkyl iodides might play a similar role to that played by iodine. Hence those carbonyls known to react with iodine to give complex iodides should react with perfluoroalkyl iodides to yield perfluoroalkyl derivatives of transition metals. To test this hypothesis we have studied reactions between perfluoropropyl and perfluoroethyl iodides and (1,2-bisdiphenylphosphinoethane)nickel dicarbonyl,[3] a representative of a class of compound known to react with iodine to afford complex metal iodides.[3,4] It was found that both of the perfluoroalkyl iodides react with the diphosphinenickel dicarbonyl, with or without a solvent, to yield air-stable complexes $(Ph_2P \cdot CH_2 \cdot CH_2 \cdot PPh_2)NiR_f \cdot I$ ($R_f = C_2F_5$ or n-C_3F_7). The new organo-nickel compounds are reddish-brown and diamagnetic, the latter property indicating a square-planar arrangement of ligands around nickel. Interestingly, these are the first fluorocarbon derivatives of a transition metal to be

[1] Part XXI, Treichel, Morris, and Stone, *J.*, 1963, preceding paper.
[2] (*a*) Manuel, Stafford, and Stone, *J. Amer. Chem. Soc.*, 1961, **83**, 249; (*b*) King, Stafford, Treichel, and Stone, *J. Amer. Chem. Soc.*, 1961, **83**, 3604.
[3] Chatt and Hart, *J.*, 1960, 1378.
[4] Chatt, Pauson, and Venanzi, Chapter 10, A.C.S. Monograph, "Organometallic Chemistry" (Ed. Zeiss), Reinhold Publishing Corporation, New York, 1960.

prepared in which the effective atomic number rule is not obeyed,[5] although more recently the presumably diamagnetic compounds $(Ph_2P{\cdot}CH_2{\cdot}CH_2{\cdot}PPh_2)Ni(CF_2)_4$ and (bipyridyl)-$Pd(n\text{-}C_3F_7)_2$ have been isolated.[6]

Isolation of our two fluorocarbon-nickel iodides as crystalline materials, reasonably stable to air and heat, is significant in view of the fact that alkyl-nickel complexes have only a transient existence.[7] These perfluoroalkyl-nickel compounds provide a particularly good example of the stabilization of a transition metal–carbon σ-bond by the presence of fluorine atoms on carbon.

Experimental.—(1,2-*bisdiphenylphosphinoethane*)-*Iodoperfluoropropylnickel.* (1,2-Bisdiphenylphosphinoethane)nickel dicarbonyl [3] (1·5 g., 3·0 mmoles) was dissolved in benzene (35 ml.). Perfluoropropyl iodide (6 g., 20 mmoles) was added, and the mixture was stirred under nitrogen at room temperature for 30 min. Solvent was removed at reduced pressure, leaving a rust-coloured solid whose infrared spectrum showed a weak carbonyl absorption indicating the presence of a small amount of the starting diphosphine-nickel dicarbonyl. The desired (1,2-*bisdiphenylphosphinoethane*)-*iodoperfluoropropylnickel* [Found: C, 46·1; H, 2·8; F, 18·0; Ni, 7·6; I, 17·3%; *M* (isopiestic), 740. $C_{29}H_{24}F_7INiP_2$ requires C, 46·2; H, 3·2; F, 17·7; Ni, 7·8; I, 16·9%; *M*, 753], m. p. 220—222° (decomp.), was obtained (1·9 g., 84%) by recrystallization from benzene.

The compound was also prepared as follows. The diphosphine-nickel dicarbonyl (2·6 g., 5·1 mmoles) and perfluoropropyl iodide (12 g., 40 mmoles) were sealed in an evacuated Pyrex bulb of 300 c.c. capacity. The bulb was left at room temperature for 60 hr., and the red-brown product (3·5 g., 92%) recrystallized from benzene as needles.

Iodoperfluoroethyl-(1,2-*bisdiphenylphosphinoethane*)*nickel.* A solution of the diphosphine-nickel dicarbonyl (5·2 g., 10 mmoles) in dichloromethane (15 ml.) was placed in a 150 c.c. steel bomb. The bomb was attached to the vacuum-line, evacuated, and charged with perfluoroethyl iodide (3 g., 12 mmoles), then heated at 70° for 24 hr., after which its contents were removed with the aid of additional dichloromethane. After filtration, solvent was removed at 25°/15 mm. and the product washed with (2 × 10 ml.). Recrystallization from benzene afforded *iodoperfluoroethyl*-(1,2-*bisdiphenylphosphinoethane*)*nickel* (Found: C, 48·0; H, 3·7; F, 13·3. $C_{28}H_{24}F_5INiP_2$ requires C, 47·8; H, 3·4; F, 13·5%) as reddish-brown needles (4·9 g., 70%), decomposing, without melting, above 260°.

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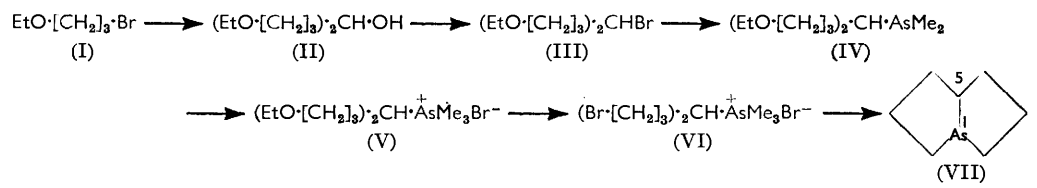
[5] King, Pitcher, Stafford, Treichel, and Stone, " Advances in the Chemistry of the Coordination Compounds " (Ed. Kirschner), Macmillan, New York, 1961, p. 619.
[6] Stone, McBride, Pitcher, Plowman, and Treichel, Proceedings Second International Symposium on Fluorine Chemistry, 1962, p. 192; Maitlis and Stone, *Chem. and Ind.*, 1962, 1865.
[7] Chatt and Shaw, *J.*, 1960, 1718.

118. *The Synthesis of* 1-*Arsabicyclo*[3,3,0]*octane.*

By Denys M. Heinekey, Ian T. Millar, and Frederick G. Mann.

Few heterocyclic derivatives of arsenic are known in which the arsenic atom is common to two fused rings: 7-methoxy-1,6-dioxoarsulolidine and certain related polycyclic compounds have been described by Mann and Wilkinson.[1] We now record the synthesis in very low yield of a simple compound of this type, 1-arsabicyclo[3,3,0]octane (1-arsapentalane) (VII).

1-Bromo-3-ethoxypropane (I) yielded a Grignard reagent which with ethyl formate gave 1,7-diethoxyheptan-4-ol (II), and this with phosphorus tribromide yielded 4-bromo-1,7-diethoxyheptane (III). The bromide (III) did not react readily with magnesium in diethyl ether, but by heating it with an excess of the metal and methyl iodide as entraining agent, the derived Grignard reagent was formed in *ca.* 50% yield. When this Grignard



reagent was treated with dimethyliodoarsine, it gave 4-dimethylarsino-1,7-diethoxypentane (IV), which was purified through formation and thermal decomposition of its quaternary methobromide. The arsine (IV) and the other arsines described in this paper give quaternary methohalide salts which are hygroscopic and which we failed to recrystallize from common solvents. All, except the arsine (VII), gave intractable methopicrates. When the arsine (IV) was heated with hydrobromic acid, and the solvent then removed and the residue heated, it gave 1,7-dibromo-4-dimethyl-arsinopentane; we were not able to detect the formation in this reaction of the methobromide of the bicyclic arsine (VII) or the free arsine (VII) itself which would result from it by elimination of methyl bromide.

However, when the methobromide (V) of the arsine (IV) was heated with hydrobromic acid, a quaternary salt, which was almost certainly the trimethylarsonium bromide (VI), was formed. When this salt was heated at 200°, it doubtless underwent loss of methyl bromide followed by cyclic quaternization, and these processes were then repeated since the distillate contained 1-arsabicyclo[3,3,0]octane (VII), and the residue contained its methobromide.

The bicyclic arsine (VII) was formed in very low yield, which was not improved by modification of the conditions of the experiment. This very low yield and the ready oxidation of the arsine make the isolation of the pure material difficult, and it was therefore characterized as the quaternary methopicrate and as the binuclear palladium bromide complex, $[(C_7H_{13}As)_2(PdBr_2)_2]$: these derivatives are stable to air and not hygroscopic.

Many types of arsenic compound readily cyclize to form five-membered rings;[2] consequently the relative failure of the reactions now described may result from a tendency for the cyclized intermediate bromides to undergo thermal decomposition mainly by paths involving ring disruption, rather than by simple elimination of methyl bromide.

Experimental.—Reactions and purifications of arsines were carried out under nitrogen. M. p.s were determined on a Kofler heated stage.

1,7-*Diethoxyheptan*-4-*ol* (II). 1-Bromo-3-ethoxypropane[3] (100 g., 0·6 mol.) in ether (125

[1] Mann and Wilkinson, *J.*, 1957, 3336, 3346.

[2] Emrys R. H. Jones and Mann, *J.*, 1955, 401, 405, 411; Mann, "The Heterocyclic Derivatives of Phosphorus, Arsenic, Antimony, Bismuth, and Silicon," Interscience Publishers, New York, 1950, p. 58.

[3] Anderson, Crawford, and Sherrill, *J. Amer. Chem. Soc.*, 1946, **68**, 1294.

ml.) was added to magnesium (14·5 g., 0·6 g.-atom) under ether (200 ml.) at such a rate that the ether boiled gently. The mixture was then stirred for 15 min. before ethyl formate (21 g., 0·3 mol.) in ether (50 ml.) was added during 30 min. A viscous complex separated. After a further 10 minutes' stirring, water (50 ml.) was added without cooling and with vigorous stirring, and then sulphuric acid (35 g., 0·35 mol.) in water (200 ml.) during 45 min. without cooling. The organic layer was separated and the aqueous layer extracted with ether; the solvent was removed from the combined organic layers, and the residue of impure alcohol was boiled under reflux with aqueous 15% potassium hydroxide (50 ml.) for 90 min. The organic layer was separated, dried (K_2CO_3), and fractionated, giving the *alcohol* (II) (35 g., 57%), b. p. 147—148°/16 mm. (Found: C, 64·3; H, 11·9. $C_{11}H_{24}O_3$ requires C, 64·6; H, 11·85%).

4-Bromo-1,7-diethoxyheptane (III). A mixture of the alcohol (II) (58 g.) and dry pyridine (3 ml.) was added with stirring to phosphorus tribromide (25 g.) at 60—80°, and the mixture set aside overnight before being poured into water. The organic layer, combined with an ethereal extract from the aqueous layer, was dried (Na_2SO_4) and fractionated, yielding the *bromide* (III) (55 g., 76%), b. p. 141—142°/15 mm. (Found: C, 49·9; H, 8·9. $C_{11}H_{23}BrO_2$ requires C, 49·4; H, 8·7%).

Reaction of 4-bromo-1,7-diethoxyheptane with magnesium. The bromide (III) (10 g.) and methyl iodide (1 ml.) in ether (100 ml.) were added during 3 hr. to magnesium (3 g., 3·3 atoms) under ether (25 ml.), and the mixture was stirred for 12 hr. before being poured on solid carbon dioxide and ether. Working up in the usual way gave 1,7-diethoxyheptane-4-carboxylic acid (4·4 g., 50%), b. p. 123°/0·01 mm. (lit.,[4] b. p. 169°/0·08 mm.) (Found: C, 62·1; H, 10·7. Calc. for $C_{12}H_{24}O_4$: C, 62·0; H, 10·4%).

In a similar experiment in which only 0·91 g. (1 atom) of magnesium was used, the yield was 30%; and if the methyl iodide was omitted also, the yield of crude acid was 4%.

4-Dimethylarsino-1,7-diethoxyheptane (IV). The bromide (III) (20 g.) and methyl iodide (1 ml.) in ether (200 ml.) were added during 3 hr. to magnesium (4 g.) under ether (50 ml.), and the mixture was boiled under reflux for 1 hr. After cooling, dimethyliodoarsine (17 g.) in benzene (50 ml.) was added, and the mixture was again boiled for 1 hr. Hydrolysis with saturated aqueous ammonium chloride gave an organic layer which was dried and fractionated; no pure fraction was obtained,.the whole of the product (after removal of solvents) distilling at 140—160°/16 mm. This crude arsine gave, with methyl bromide or methyl iodide, salts which were hygroscopic and failed to crystallize from common solvents. The whole of the crude arsine was therefore heated with an excess of methyl bromide in a sealed tube at 100° for 3 hr., and the resulting crude methobromide (V) was washed with ether, dried, and decomposed by heating under nitrogen at 230°/0·2 mm., the distillate being collected at −50°. This distillate, when fractionally distilled, gave the *arsine* (10 g., 48%), b. p. 144—146°/13 mm. (Found: C, 53·3; H, 10·2. $C_{13}H_{29}AsO_2$ requires C, 53·4; H, 10·0%).

When the pure arsine (IV) (10 g.) was boiled with 48% hydrobromic acid (200 ml.) under reflux for 2 hr., and the acid then removed under reduced pressure, a red sticky residue remained. This was heated at 210°/13 mm., giving a small amount of distillate containing some arsenic; fractionation of this distillate gave an arsine, doubtless *1,7-dibromo-4-dimethylarsinoheptane*, b. p. 120°/15 mm., in yields never exceeding 0·5 g. (Found: C, 31·0; H, 5·5. $C_9H_{19}AsBr_2$ requires C, 30·1; H, 5·3%). The methiodide and methobromide are hygroscopic and did not crystallize.

1-Arsabicyclo[3,3,0]octane (VII). The trimethylarsonium bromide (V), prepared from the bromide (III) (20 g.), was boiled under reflux with hydrobromic acid (48%, 200 ml.) for 2 hr., and the acid then removed under reduced pressure. The residue was heated at 200°/0·1 mm., giving a small quantity of distillate containing arsenic collected at −30° and −50°. Dissolution of the distillate in benzene, filtration, and removal of the solvent gave a liquid (*ca.* 0·2 ml.) which on fractionation gave the crude arsine (VII), b. p. 100—102°/17 mm. (Found: C, 44·5; H, 6·0. Calc. for $C_7H_{13}As$: C, 48·9; H, 7·55%); this rapidly became turbid when exposed to air. With hot aqueous ethanolic potassium palladobromide it readily gave the red crystalline *dibromobis-(1-arsabicyclo[3,3,0]octane)-μμ′-dibromodipalladium*, m. p. 150° after being washed with water, ethanol, and ether (Found: C, 19·45; H, 3·3. $C_{14}H_{26}As_2Br_4Pd_2$ requires C, 19·4; H, 3·0%). No suitable solvent for recrystallization of this complex was found.

The residue from the thermal decomposition was washed with ether, and its solution in

[4] Prelog and Heinbach, *Ber.*, 1939, **72***B*, 1101.

ethanol mixed with ethanolic sodium picrate; 1-*methyl*-1-*arsoniabicyclo*[3,3,0]*octane picrate monohydrate* was deposited as yellow crystals, m. p. 232° (from water) (Found: C, 39·0; H, 4·6; N, 9·95. $C_{14}H_{18}AsN_3O_7H_2O$ requires C, 38·8; H, 4·6; N, 9·7%).

Modifications in the temperature of the thermal decomposition, the rate of heating, and the apparatus did not improve yields of the arsine (VII).

From decomposition in a sealed tube at 170° for 12 hr., or at 190° for 18 hr., the only product isolated was tetramethylarsonium bromide, not melting below 350° (from ethanol) (Found: C, 22·5; H, 5·4; ionic Br, 38·4. Calc. for $C_4H_{12}AsBr$: C, 22·4; H, 5·65; Br, 37·2%). With ethanolic sodium picrate this gave yellow *tetramethylarsonium picrate*, m. p. 290° (from water) (Found: 33·35; H, 3·8; N, 11·8. $C_{10}H_{14}AsN_3O_7$ requires C, 33·1; H, 3·9; N, 11·6%).

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DEPARTMENT OF CHEMISTRY,
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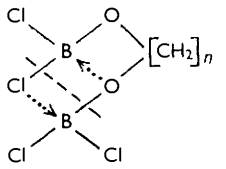
119. *Disproportionation of Bisborates and Bisborinates.*

By ARTHUR FINCH, P. J. GARDNER, and J. C. LOCKHART.

ETHYLENE BIS(DICHLOROBORINATE) (I; $n = 2$, X = Cl) has been shown [1] to possess considerable stability at room temperature, and the derived ester, ethylene bis(dibutyl borate) (I; $n = 2$, X = OBu^n), to be stable to repeated distillation.[1, 2] We have attempted to prepare the corresponding trimethylene systems (I; $n = 3$, X = Cl, NCS, or OBu^n) and have found a striking difference in thermal stability.

$$X_2B{\cdot}O{\cdot}[CH_2]_n{\cdot}O{\cdot}BX_2 \quad (I)$$

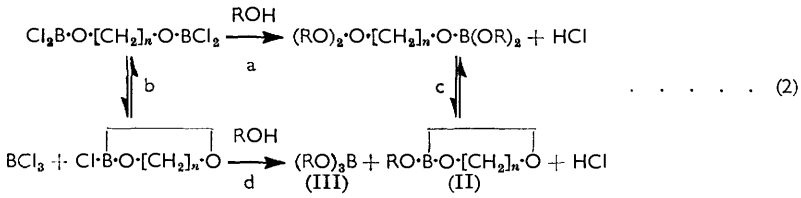
Although the infrared spectrum of the product of reaction of appropriate quantities of boron trichloride and trimethylene glycol indicated formation of the discrete compound trimethylene bisdichloroborinate (I; $n = 3$, X = Cl), decomposition into 2-chloro-1,3,2-dioxaborinan and boron trichloride proceeded rapidly at room temperature, possibly as indicated in scheme (1). Trimethylene bisdi-isothiocyanatoborinate (I; $n = 3$, X = SCN) appeared to disproportionate similarly.



$$\rightleftharpoons \quad BCl_3 + Cl{\cdot}B{\cdot}O{\cdot}CH_2{\cdot}CH_2{\cdot}O \qquad \cdots\cdot(1)$$

We attempted to make trimethylene bis(di-2-chloroethyl borate) by condensation of the trimethylene bisdichloroborinate (I; $n = 3$, X = Cl) with 2-chloroethanol. The infrared spectrum and refractive index of the product were identical with those of an equimolar mixture of 2-2′-chloroethoxy-1,3,2-dioxaborinan and tris-2-chloroethyl borate. On distillation these were separated and identified as the sole products. Reaction of the trimethylene bis(dichloroborinate) and butan-1-ol likewise yielded the corresponding cyclic ester (II; R = Bu^n). We cannot distinguish between the two reaction paths shown in (2); either or both of them may be operative.

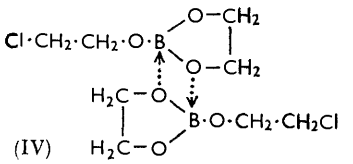
[1] Blau, Gerrard, and Lappert, *J.*, 1960, 667.
[2] Blau, Gerrard, and Lappert, *J.*, 1957, 4116.



. . . . . (2)

This instability of trimethylene bis(dialkyl borates) is in sharp contrast to the behaviour of the ethylene compound (I; $n = 2$, X = OBu^n). That thermal stability is not a simple function of chain-length was shown by the attempted preparation of the ethylene bis(di-2-chloroethyl borate) (I; $n = 2$, X = $O{\cdot}[CH_2]_2{\cdot}Cl$). Tris-2-chloroethyl borate and 2-2′-chloroethoxy-1,3,2-dioxaborolan were the only products. Tetramethylene bisdichloroborinate was not thermally stable, and disproportionation as in (1) is assumed.

The disproportionation product 2-2′-chloroethoxy-1,3,2-dioxaborolan (IV), synthesised by an independent method, was shown by cryoscopic measurements in benzene solution (0·1—0·25M) to be a dimer. Chloroethyl and chloropropyl boronates and borinates are known to possess greater thermal stability than esters with no terminal chlorine. Thus 2-ethoxy-1,3,2-dioxaborinan could not be obtained pure, whilst 2-2′-chloroethoxy-1,3,2-dioxaborinan was stable on distillation.[3, 4] It has been suggested that this may be due in part to chelation, with back-donation from chlorine to boron. This is unlikely in ester (IV) where association presumably results as shown, from boron–oxygen bonding. Infrared examination of associated molecules of this type is in progress.



(IV)

Experimental.—Trimethylene bisdichloroborinate. Propane-1,3-diol (3·3 g.) was added dropwise to boron trichloride (10·3 g.) at −80° under a condenser cooled to −80°. Hydrogen chloride evolved (100%) was estimated volumetrically. The *compound* was stored at −80° (Found: B, 9·1; Cl, 58·3. $C_3H_6B_2Cl_4O_2$ requires B, 9·1; Cl, 59·7%) and had n_D^{25} 1·4418. The infrared spectrum differed from those of the disproportionation products, dioxaborinan [4] and boron trichloride, there being intensity changes and frequency shifts near 780, 1025, and 1100 cm.$^{-1}$.

Attempted preparation of trimethylene bis(di-2-chloroethyl borate). 2-Chloroethanol (7·15 ml.) was added dropwise to trimethylene bisdichloroborinate (6·4 g.) at −80° under a condenser cooled to −80°. Hydrogen chloride evolved was estimated volumetrically (84%). The liquid product, n_D^{25} 1·4500, was analysed before distillation (Found: B, 5·3. $C_{11}H_{22}B_2Cl_4O_6$ requires B, 5·2%). The infrared spectrum (0·125M-solution in CCl_4) was quantitatively similar to the superimposed spectra of the disproportionation products. The product was distilled under reduced pressure, boiling over the range 25—75°/0·1 mm., and the centre fraction was refluxed at 180° for 5 hr. After several refractionations, the centre fraction distilled over the same range, leaving no residue. The lowest-boiling fraction, n_D^{25} 1·4481, b. p. 48—50°/0·07 mm., was shown to be principally 2-2′-chloroethoxy-1,3,2-dioxaborinan [4] by analysis (Found: B, 6·2. Calc. for $C_5H_{10}BClO_3$: B, 6·6%) and comparison of its infrared spectrum with that of an authentic sample. The highest-boiling fraction, b. p. 70—80°/0·1 mm., n_D^{25} 1·4520, was identified as tris-2-chloroethyl borate [5] by analysis (Found: B, 4·8. Calc. for $C_6H_{12}BCl_3O_3$: B, 4·3%) and by its infrared spectrum. 83% of the theoretical quantity of tris-2-chloroethyl borate (calc. on reaction 2c) was recovered.

Attempted preparation of trimethylene bis(di-n-butyl borate). The reaction was conducted in a similar manner with butan-1-ol (15·4 ml.) and trimethylene bisdichloroborinate (8·7 g.). Hydrogen chloride (78%) was evolved. Repeated refractionation under reduced pressure effected separation into tri-n-butyl borate, n_D^{25} 1·4079, b. p. 48—52°/0·1 mm. (lit.,[5] n_D^{25} 1·4070)

[3] Finch, Gardner, Lockhart, and Pearn, *J.*, 1962, 1428.
[4] Finch, Lockhart, and Pearn, *J. Org. Chem.*, 1961, **26**, 3250.
[5] Gerrard and Lappert, *Chem. and Ind.*, 1952, 53.

(infrared spectrum identical with that of an authentic sample, which boiled at 50—52°/0·1 mm.), and 2-n-butoxy-1,3,2-dioxaborinan, b. p. 34—37°/0·06 mm. (lit.,[4] b. p. 36—38°/0·12 mm. (infrared spectrum identical with that of an authentic sample).

Trimethylene bis(di-isothiocyanatoborinate). Trimethylene bisdichloroborinate (3·9 g.) was run into a solution of potassium thiocyanate (6·4 g.) in 1,2-dimethoxyethane (100 ml.). Precipitated potassium chloride was filtered off and the solvent evaporated from the filtrate. The residue was distilled into four fractions, the highest of which was 2-isothiocyanato-1,3,2-dioxaborinan, b. p. 55—65/0·05 mm., which had an infrared spectrum identical with that of an authentic sample.[3] Boron tri-isothiocyanate has only very recently been described.[6]

Ethylene bis[di-(2-chloroethyl) borate]. Ethylene bisdichloroborinate (Found: B, 9·3, Cl, 61·5. Calc. for $C_2H_4B_2Cl_4O_2$: B, 9·7; Cl, 63·6%) was esterified with 2-chloroethanol as before; hydrogen chloride (93%) was evolved. Successive fractionation yielded 2-2′-chloroethoxy-1,3,2-dioxaborolan, b. p. 52—56°/0·02 mm., n_D^{25} 1·4565, identical in infrared spectrum with that obtained by another route (below), followed by tris-2-chloroethyl borate, b. p. 68°/0·05 mm., n_D^{25} 1·4520 (lit., b. p. 70°/0·01 mm., n_D^{25} 1·4530) (Found: B, 4·3. Calc.: B, 4·6%).

2-2′-Chloroethoxy-1,3,2-dioxaborolan.—Prepared from 2-chloro-1,3,2-dioxaborolan and 2-chloroethanol by a standard method, this *ester* was a colourless viscous liquid, b. p. 52—58°/0·02 mm., n_D^{25} 1·4554 (Found: C, 31·9; H, 5·7; B, 7·05; Cl, 24·75%; *M*, 290. $C_4H_8BO_2Cl$ requires C, 31·95; H, 5·4; B, 7·2, Cl, 23·6%; *M*, 150).

Tetramethylene bisdichloroborinate. Butane-1,4-diol (3·0 ml.) was added to boron trichloride (8·1 g.) at −80° under a condenser cooled to −80°. Hydrogen chloride (84%) was evolved and the residual *ester*, a white amorphous fuming solid, darkened rapidly at room temperature (Found: B, 8·7; Cl, 53·9. $C_4H_8B_2Cl_4O_2$ requires B, 8·6; Cl, 56·3%).

Physical constants. Molecular weights were determined cryoscopically in benzene, and infrared spectra were investigated between 3000 and 700 cm.$^{-1}$ on a Perkin-Elmer model 137 spectrometer.

The authors are grateful for the award of a University of London I.C.I. Fellowship (to J. C. L.) and a Petroleum Research Fund Studentship (to P. J. G.). It is a pleasure to thank Messrs. B. Smethurst and R. D. G. Lane for technical assistance.

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[6] Sowerby, *J. Amer. Chem. Soc.*, 1962, **84**, 1831; cf. Cocksedge, *J.*, 1908, **93**, 2177; Pohland, *Z. anorg. Chem.*, 1931, **201**, 282.

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120. *The Reaction of Diazomethane with Water.*

By ASHARAM BHATI.

ANOMALOUSLY dimethyl succinate was obtained on reaction of diazomethane and succinic anhydride. Previous work [1] as well as author's own experiments [2] suggested that this was due to methanol which is invariably present in ethereal diazomethane prepared in the usual way, arising from reaction of diazomethane with water. It has now been found that diazomethane indeed reacts with water, yielding methanol, nitrogen, polymethylene, etc. von Pechmann [3] had earlier observed the ready decomposition of diazomethane with water, but he did not examine the products.

Experimental.—Diazomethane was prepared from nitrosomethylurea, 50% aqueous potassium hydroxide and ether. In order to ensure the absence of methanol, the nitrosomethylurea was washed with ice–water, and the ether was shaken with water, dried ($CaCl_2$), and distilled. The purity of ether was checked by infrared spectroscopy and gas-chromatography. The ethereal solution of diazomethane was distilled (bath-temp. < 50°) and the distillate dried (KOH) for 2 hr. Diazomethane was estimated by reaction with benzoic acid.

[1] Bradley and Robinson, *J. Amer. Chem. Soc.*, 1930, **52**, 1558.
[2] Bhati, *J. Org. Chem.*, 1962, **27**, 1183.
[3] von Pechmann, *Ber.*, 1894, **27**, 1888; see also Meerwein and Burnleit, *ibid.*, 1928, **61**, 1840.

(i) On treatment with distilled water (35 ml.) at 11°/750 mm. diazomethane (0·4300 g. in 20 ml. of ether) evolved, during 30 min., one mol. (244 ml.) of nitrogen. (ii) Diazomethane (4·2540 g. in 162 ml. of ether) was treated with distilled water (1·90 g.) at 0° and left at 20° for 70 hr. Control experiments showed considerable loss of diazomethane due to evaporation and evolution of nitrogen. The colourless mixture (112 ml.) contained some unused water, polymethylene (0·0380 g., identified by infrared spectroscopy), and methanol (identified as methyl 3,5-dinitrobenzoate, m. p. and mixed m. p. 109°). The yield of methanol on the basis of the 3,5-dinitrobenzoate was 19·6%, and as determined by gas-chromatography (25% of polybutylene glycol on 30—80 mesh alkali-washed fire-brick at 67°, with argon as carrier) was 20·2%. The reaction mixture also contained an unidentified low-boiling compound which was eluated after ether but before methanol.

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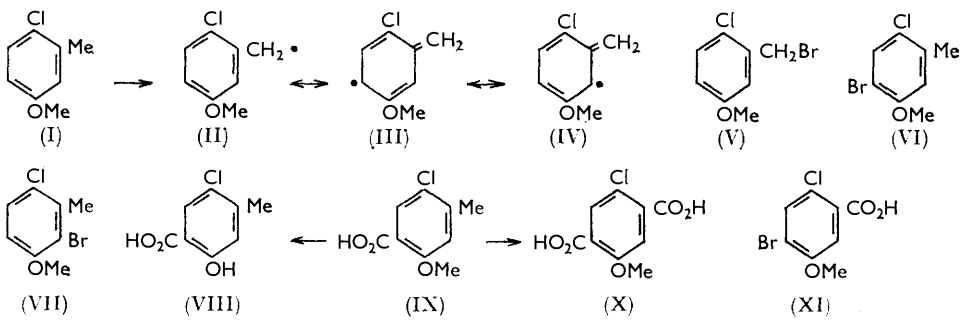
121. *The Course of Bromination of 4-Chloro-3-methylanisole with N-Bromosuccinimide.*

By ASHARAM BHATI.

ACCORDING to Boothe *et al.*[1,2] the peroxide-catalyzed reaction of 4-chloro-3-methylanisole (I) with *N*-bromosuccinimide results in side-chain bromination, and 2-chloro-5-methoxybenzyl bromide (V) is obtained in 93% yield. During work on tetracyclines we too studied this bromination and found that the product comprised a mixture of the bromide (V) and the nuclear isomer (VI). The bromination was carried out under various conditions but always a mixture of isomers (V and VI) was obtained: formation of isomer (VI) was



greater when the bromination was done in a quartz-vessel under irradiation with ultraviolet light. This bromide (VI) does not seem to have been reported previously. Its structure is based on the following observations: (1) It did not react with diethyl sodiomalonate, indicating that the bromine was situated in the nucleus.* (2) On treatment with magnesium and carbonation of the Grignard complex, it gave a monocarboxylic acid, $C_9H_9ClO_3$, that was demethylated to a hydroxy-acid, $C_8H_7ClO_3$, giving a violet colour with ferric chloride and an infrared carbonyl band at 1670 cm.$^{-1}$; the hydroxyl and

* This property enabled it to be separated from the benzyl bromide (V).

[1] Boothe, Kende, and Fields, *J. Amer. Chem. Soc.*, 1959, **81**, 1006.
[2] Wilkinson, Fields, and Boothe, *J. Org. Chem.*, 1961, **26**, 637.

carboxyl groups thus being *ortho* to one another.[3] (3) The parent methoxy-acid gave, with alkaline permanganate, a dicarboxylic acid, $C_9H_7ClO_5$, m. p. 278°, which did not give an anhydride and is, therefore, not the known 6-chloro-3-methoxyphthalic acid,[4] m. p. 186—187°, a degradation product of aureomycin; the carboxyl groups of this acid must, therefore, be *para* to one another, and hence it must be represented by (X); the methoxy- and hydroxy-acids, consequently, should have structures (IX and VIII), respectively. The bromide (VI) gave with permanganate an acid, $C_8H_6BrClO_3$, which must be represented by (XI).

The concomitant formation of the isomers (V) and (VI) might be due to partial rearrangement of the initially formed [5] radical (II) to (III). For steric reasons the formation of the alternative (VII) from radical (IV) is not likely to be favoured, and apparently does not occur. Alternatively, the bromide (VI) might arise by the action of molecular bromine which has been postulated [6] as an intermediate in reactions of *N*-bromosuccinimide. Attempts to determine by which of these two routes is followed have not led to an unambiguous conclusion. 4-Chloro-3-methylanisole reacted sluggishly with bromine in carbon tetrachloride at 25° to yield a mixture consisting mainly of the bromide (VI). Thermal isomerization of the benzyl bromide (V) at 450° in nitrogen gave a mixture, m. p. 33—46°, which probably contained both bromides.

Experimental.—M. p.s were determined on a Kofler block. Ultraviolet spectra refer to 95% ethanol solution and were determined on a Unicam S.P. 500 spectrophotometer. The infrared spectrum refers to chloroform solution and was determined on a Perkin-Elmer Infracord instrument. Anhydrous sodium sulphate was used for drying solutions. Elemental analyses are by Mr. J. M. L. Cameron and staff whom I thank.

4-Chloro-3-methylanisole (I). 4-Chloro-3-methylphenol (150 g.), sodium hydroxide (153 g.), water (200 ml.), and freshly distilled dimethyl sulphate (138 ml.) were heated with stirring on a steam-bath for 8 hr. and then set aside for 50 hr. The neutral product (151 g.), isolated in the usual way, gave on distillation the ether (147·4 g.), b. p. 214—216°, 60—62°/0·05 mm., $n^{23\cdot5}$ 1·5351, $\lambda_{max.}$ 229, 280—281, 288 mμ (log ε 3·99, 3·29, 3·25).

Bromination of 4-chloro-3-methylanisole. This was carried out under a variety of conditions, some of which were similar to those employed by Wilkinson *et al.*[2] Only the experiment in which a quartz flask and ultraviolet irradiation were used is described. The source of radiation was an Osram 125 w mercury discharge lamp provided with a glass ultraviolet-filter, giving 95% of the radiation at 3650 Å. 4-Chloro-3-methylanisole (97·3 g.) and *N*-bromosuccinimide (111·3 g.) in dry carbon tetrachloride (200 ml.) were refluxed under anhydrous conditions for 5 hr., then cooled and filtered. The solid was washed with carbon tetrachloride (50 ml.). The reddish filtrate and washings were combined and the solvent was distilled *in vacuo*. The oily lachrymatory residue (144·1 g.) gave, on fractional distillation, a forerun (33·1 g.), b. p. up to 74°/0·1 mm. and fractions (i), b. p. 74—80°/0·1 mm. (97 g.), n^{24} 1·5809, and (ii) b. p. 80—90°/0·1 mm. (2·7 g.). Gas-chromatography showed fraction (i) to consist of two compounds. Refluxing it with 2N-sodium hydroxide for 2 hr. and back-titrating the unused alkali, showed the amount of isomer (V) to be 62·7%.

2-Chloro-5-methoxybenzaldehyde. Fraction (i), mentioned above, gave on treatment with hexamine a solid complex which gave on decomposition with acid [7] *2-chloro-5-methoxybenzaldehyde* which was obtained on sublimation at 50°/0·1 mm. as plates, m. p. 63° (Found: C, 56·4; H, 4·7. $C_8H_7ClO_2$ requires C, 56·3; H, 4·1%) [*2,4-dinitrophenylhydrazone*, orange prisms, m. p. 210—212° (Found: C, 48·1; H, 3·4; N, 15·2. $C_{14}H_{11}N_4ClO_5$ requires C, 47·9: H, 3·1; N, 16·0%].

2-Bromo-4-chloro-5-methylanisole (VI). This component was isolated either by repeated

[3] Salicylic acid absorbs at 1655 cm.$^{-1}$ (L. J. Bellamy, " The Infra-red Spectra of Complex Molecules," Methuen and Co. Ltd., London, 2nd edn., 1958, p. 169).

[4] Hutchings, Waller, Gordon, Broschard, Wolf, Goldman, and Williams, *J. Amer. Chem. Soc.*, 1952, **74**, 3710.

[5] Goldfinger, Gosselain, and Martin, *Nature*, 1951, **168**, 30.

[6] Adan, Gosselain, and Goldfinger, *Nature*, 1953, **171**, 704; McGrath and Tedder, *Proc. Chem. Soc.*, 1961, 80.

[7] Doukas, *J. Chem. Educ.*, 1954, **31**, 12.

fractional distillation of the crude bromination product or by treating it with diethyl sodiomalonate [the isomer (V) underwent condensation]. The low-boiling portion of the condensation mixture was refluxed with alkali in order to remove traces of ester impurities. The neutral product so obtained mostly consisted of the *bromide* (VI), that formed prisms, m. p. 45°, $\lambda_{max.}$ 229, 287, and 294 mμ (log ε 3·99, 3·48, 3·45), on recrystallisation from light petroleum (b. p. 40—60°) or sublimation at 40°/0·2 mm. (Found: C, 40·6; H, 3·55. C_8H_8BrClO requires C, 40·8; H, 3·4%).

5-*Chloro*-2-*methoxy*-4-*methylbenzoic acid* (IX). The bromide (VI) (2·24 g.), magnesium (0·69 g.), ethyl bromide (0·72 ml.), and dry tetrahydrofuran (40 ml.) were refluxed for 4 hr., set aside for 1·5 hr., and then poured on powdered carbon dioxide (*ca.* 100 g.). The unchanged magnesium was washed with dry tetrahydrofuran (10 ml.), and the washings were also added to carbon dioxide. Next morning the reaction mixture was treated with 6N-sulphuric acid (15 ml.) and extracted with ether (250 ml.). The extract was shaken with saturated sodium carbonate solution (100 ml.). On drying and removal of solvents a liquid (0·69 g.) was obtained but not examined. The alkaline extract was acidified with concentrated sulphuric acid (20 ml.) and extracted with ether (2 × 150 ml.), giving a white solid (0·90 g.), m. p. 128—133°. On recrystallisation from benzene this *acid* formed plates, m. p. 136—137° (Found: C, 54·0; H, 4·25. $C_9H_9ClO_3$ requires C, 53·9; H, 4·5%).

5-*Chloro*-2-*hydroxy*-4-*methylbenzoic acid* (VIII). The above-mentioned acid (254 mg.) was heated with constant-boiling hydriodic acid (5 ml.) on the steam-bath for 4 hr. The mixture was diluted with water (40 ml.) and extracted with ether (80 ml.). The ethereal solution was washed with 10% sodium thiosulphate solution (20 ml.) and water, dried, and evaporated, giving the *hydroxy-acid* (205 mg.), needles, m. p. 210—212° (from dilute methanol) (Found: C, 51·0; H, 4·3. $C_8H_7ClO_3$ requires C, 51·5; H, 3·75%).

2-*Chloro*-5-*methoxyterephthalic acid* (X). The methoxy-acid (IX) (245 mg.) was heated in saturated sodium carbonate solution (20 ml.) with 2% potassium permanganate solution (60 ml.) on a steam-bath for 4 hr. The excess of permanganate was destroyed by methanol. The manganese dioxide sludge was filtered off and washed with water (20 ml.). The filtrate and washings were combined, concentrated to *ca.* 10 ml., and acidified with 6N-sulphuric acid. The liberated *acid* (202 mg.) was extracted with ether (75 ml.) and recrystallised from ethyl acetate as flakes, m. p. 278° (rapid heating). The resolidified melt melted at *ca.* 278° (Found: C, 46·95; H, 3·1. $C_9H_7ClO_5$ requires C, 46·9; H, 3·0%). With diazomethane it gave the *dimethyl ester*, forming prisms, m. p. 84—85°, on sublimation at 130°/0·1 mm. (Found: C, 51·1; H, 4·2. $C_{11}H_{11}ClO_5$ requires C, 51·1; H, 4·25%).

4-*Bromo*-2-*chloro*-5-*methoxybenzoic acid* (XI). The bromide (VI) was oxidised with 4% potassium permanganate at 100°. The resultant *acid*, isolated as described above, recrystallised from benzene as needles, m. p. 197—198° (Found: C, 36·4; H, 2·6. $C_8H_6BrClO_3$ requires C, 36·2; H, 2·3%).

I thank the University of Glasgow for the Pfizer Research Fellowship and Professor R. A. Raphael and Drs. A. I. Scott and A. C. Rodriguez for their interest.

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122. *Dimorphism of (±)-Laudanosine Methiodide.*

By J. M. Z. Gladych.

Pictet and Athanasescu [1] reported that laudanosine reacted with methyl iodide in boiling methanol to give laudanosine methiodide which on recrystallisation had m. p. 215—217° (later workers [2] were in close agreement); a higher-melting form is now described.

While the infrared spectra of the two forms in bromoform solution were virtually identical, as expected, the solid state spectra for a mineral oil mull showed significant differences, especially in the region 1000—700 cm.$^{-1}$. This behaviour is often characteristic of different crystalline forms.[3]

Experimental.—*(±)-Laudanosine methiodide.* (*a*) Tetrahydropapaverine hydriodide (47·0 g., 0·1 mole) was heated with sodium hydroxide (16 g., 0·4 mole), water (100 ml.), and benzene (50 ml.) on a steam-bath. Dimethyl sulphate (12·6 g., 0·1 mole) was added dropwise, with stirring, to the cooled mixture at 21—24° during 40 min. The mixture was stirred for a further 5 hr. and set aside overnight. The solid [4] was filtered off, made into a slurry with benzene, and filtered off again. The benzene-insoluble methiodide (11·0 g.) had m. p. 225—227°. After three recrystallisations from water it had m. p. 228·5—229·5° (Found: C, 53·1; H, 6·1; I, 25·55; N, 2·65; O, 12·9. Calc. for $C_{22}H_{30}INO_4$: C, 52·9; H, 6·05; I, 25·45; N, 2·8; O, 12·8%).

(*b*) (Cf. ref. 1) (±)-Laudanosine (2·0 g.) was dissolved in anhydrous methanol (40 ml.) on a steam-bath. Methyl iodide (9·2 g.) was added to the cooled solution, which was then set aside for 20 hr. The methiodide (2·4 g.) was filtered off, washed with ether, and dried at room temperature *in vacuo*. The colourless prisms had m. p. 218·5—219·5° (raised to 223—224° on admixture with the higher-melting form). A sample (1·0 g.) was dissolved in dimethylformamide (30 ml.) at 50°; after filtration and cooling, anhydrous ether (50 ml.) was added and the solution was set aside; after 20 hr. the crystalline laudanosine methiodide (0·8 g.) was collected, washed with ether and dried. It had m. p. 219·5—220°.

Conversion of the low-melting into the higher-melting form. The low-melting methiodide (1·0 g.) recrystallised from ethanol as prismatic needles, m. p. 223·5—224·5°. After two further recrystallisations from ethanol the m. p. was 228·5—229·5°, undepressed on admixture with the high-melting form.

The high-melting form (1·0 g.) was recovered unchanged when its solution in hot ethanol was cooled to 32° and seeded with a crystal of the low-melting form.

The author is grateful to the late Dr. E. P. Taylor for helpful discussions, and to Dr. J. H. Hunt and Miss P. R. Schaay for the infrared spectra.

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[1] Pictet and Athanasescu, *Ber.*, 1900, **33**, 2346.
[2] Pyman, *J.*, 1909, **95**, 1616; Craig and Tarbell, *J. Amer. Chem. Soc.*, 1948, **70**, 2783; Tomita and Yamaguchi, *Pharm. Bull.* (*Japan*), 1956, **4**, 225.
[3] Chapman, *Spectrochim. Acta*, 1957, Suppl., Proc. 6th Internat. Colloquium on Spectroscopy, Amsterdam, 1956, p. 609; Kendall, *Analyt. Chem.*, 1953, **25**, 382; Sutherland and Jones, *Discuss. Faraday Soc.*, 1950, **9**, 281; Bellamy, "The Infra-red Spectra of Complex Molecules," Methuen and Co., Ltd., London, 1959, p. 380.
[4] Gladych and Taylor, *J.*, 1962, 1481.

123. *Complexity of Dihalogenodialkoxytitanium*(IV) *Alcoholates.*

By R. N. Brown and G. Winter.

The structure of polymeric titanium(IV) alkoxides has been the subject of several recent studies.[1,2] Although the correct formulation is still open to conjecture,[3] there appears little doubt that the polymers are formed by O ⟶ Ti bridges. The methoxide,[4] ethoxide,[5] propoxide,[5] and butoxide [2] have been reported to be trimeric. It was surprising therefore, to find that dihalogenodialkoxy-derivatives of titanium(IV) are dimeric [2] and that they form very stable 1 : 1 adducts with alcohols,[6] and we now report some preliminary *X*-ray results.

Compound	System	Space group	*a* (Å)	*b* (Å)	*c* (Å)	α	β	γ	$d_{calc.}$ (g. cm.$^{-3}$) *	*Z*
$TiCl_2(OBu)_2$,BuOH	Monoclinic	$P2_1/c$	11·06	12·26	14·18	—	105·4°	—	1·21	4
$TiBr_2(OBu)_2$,BuOH	Monoclinic	$P2_1/c$	11·41	12·46	14·50	—	105·6	—	1·43	4
$TiCl_2(OEt)_2$,EtOH	Triclinic	$P\bar{1}$ or $P1$	7·20	9·57	9·98	62·9°	88·2	81·0°	1·40	2

* Calc. for the dimers; it was not possible to determine the density by the usual methods because of the great solubility in organic solvents.

We have studied the dichloro- and dibromo-dibutoxytitanium(IV) adducts with butanol and the dichlorodiethoxytitanium(IV) adduct with ethanol. Single-crystal oscillation and Weissenberg photographs were used to determine the unit cells and space groups, with the results tabulated. The values for *Z*, the number of formula units in the cell, are multiples of 2, showing that the compounds are either mono- or di-meric. Cryoscopic molecular-weight determination in benzene solution of Ti $Cl_2(OBu)_2$,BuOH (Found: *M*, 697. Calc. for dimer: *M*, 676) confirmed the dimeric nature of this compound. Thus, both the dihalogeno-esters and their alcoholates are dimeric. A full structure analysis is now being considered.

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[*Received, June 25th,* 1962.]

[1] Bradley, *Nature*, 1958, **182**, 1211.
[2] Martin and Winter, *J.*, 1961, 2947.
[3] Bradley and Westlake, *Nature*, 1961, **191**, 273; Martin and Winter, *ibid.*, p. 274.
[4] Deluzarche, Thesis, Strasbourg, 1954.
[5] Coughlan, Smith, Katz, Hodgson, and Crowe, *J. Amer. Chem. Soc.*, 1957, **73**, 5652.
[6] Nesmeyanov, Freidlina, and Nogima, *Izvest. Akad. Nauk S.S.S.R., Otdel khim. Nauk*, 1951, 518.

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124. *Ion-exchange Study of the Stability and Composition of Magnesium Citrate Complex.*

By S. K. Tobia and N. E. Milad.

Several methods have been used for the determination of the stability constants of complex citrates formed by the alkaline earths. Among these, the ion-exchange method in which radio-tracers are used was developed initially by Schubert.[1] The method, however, has not been applied to the magnesium citrate complex probably because of the relatively short half-lives of radioisotopes of magnesium. The intention of the present work was to apply the ion-exchange method to the study of the magnesium citrate complex without using radio-tracers.

[1] Schubert, *J. Phys. Colloid Chem.*, 1948, **52**, 340; Schubert and Richter, *ibid.*, p. 352; *J. Amer. Chem. Soc.*, 1948, **70**, 4259.

In experiments in which the concentration of magnesium relative to citrate and to the capacity of the cation exchanger is negligible, the simple equation derived by Schubert, Russell, and Myers [2] may be applied in the form:

$$\log [(K°_d/K_d) - 1] = \log K_c + x \log [Cit^{3-}]$$

where $K°_d$ and K_d are the distribution coefficients of magnesium in the absence and presence, respectively, of citrate, and x is the number of these ions bound per atom of magnesium.

Experimental.—Solutions. The magnesium solution was 10^{-4}M in magnesium. The citrate was prepared from diammonium hydrogen citrate and was M/30 with respect to citrate. Enough ammonium chloride and aqueous ammonia was then added to both solutions to raise the pH to 7·2 and the $[NH_4]^+$ to 0·1M.

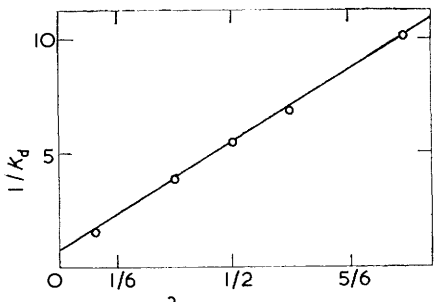

FIG. 1. Variation of $1/K_d$ with citrate concentration.

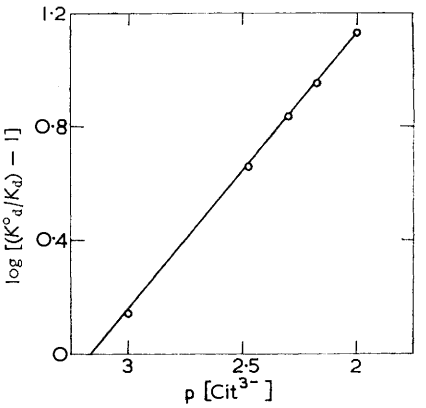

FIG. 2. Variation of $\log [(K°_d/K_d) - 1]$ with $\log [Cit^{3-}]$.

Resin. The resin used was 100—200 mesh Dowex-50, X 12 in the NH_4^+ form, and was conditioned to pH 7·2 before use. It contained 4·1 milliequivalents of NH_4 per g., and 18% of moisture as determined by drying to constant weight at 110°.

Procedure. Preliminary experiments indicated that a suitable value of $K°_d$ (*i.e.*, between 1 and 2) could be obtained by using 100 mg. of the air-dried resin and 100 ml. of the equilibrium solution. Each solution was made by adding 70 ml. of the magnesium solution to a predetermined volume of the citrate solution, and the final volume was brought to 100 ml. with 0·1M-ammonium chloride. The concentration range of citrate was 10^{-3}—10^{-2}M. In order to attain equilibrium, the mixtures were shaken for 3 hr. in an air-thermostat at 25° (±0·1°). Magnesium was determined in each solution by titrating an aliquot part with the disodium salt of ethylenediaminetetra-acetic acid after the removal of the citrate ions which inhibited the red colour of the magnesium–Eriochrome complex. This was effected by passing the test solution through a column of 70—80 mesh, Lewatit M2 strongly basic anion-exchanger in its chloride form. The column dimensions were 7 × 100 mm., and the flow rate was 2 ml. per min. Under these conditions, the uptake of the free citrate ions by the resin results in the dissociation of the citrate complex, thus liberating the magnesium ions which pass to the eluate. The values of K_d at different citrate concentrations are shown below:

$[Cit^{3-}]$, 10^{-3}M	0	1	10/3	5	20/3	10
K_d	1·43	0·62	0·26	0·18	0·15	0·098

The observed value of $K°_d$ was in good agreement with that obtained by extrapolation (Fig. 1). The plots of $\log [Cit^{3-}]$ against $\log [(K°_d/(K_d) - 1]$ (Fig. 2) indicate that the complex is of the 1 : 1 type, and the value of $\log K_c$ is 3·16. The value found by Hastings's biological method [3] was 3·2, although the variation in $[(Cit)^{3-}]$ was only two-fold whereas in the present

[2] Schubert, Russell, and Myers, *J. Biol. Chem.*, 1950, **185**, 387.
[3] Hastings, McLean, Eichelberger, Hall, and DaCosta, *J. Biol. Chem.*, 1934, **107**, 351.

experiment it was ten-fold. This suggests that the anion has no or slight effect and that higher complexes may not be involved in the equilibrium process. It is also to be expected that, among the related elements, increase in chelate stability should increase with hydrated ionic radius. The values of log K_c, determined by the ion-exchange method at 25°, are 3·4 for calcium,[4] 2·8 for strontium,[1] 2·3 for barium,[1] and 2·0 for radium.[5] This indicates that the value for magnesium is lower than would be expected. Owing to the relatively greater differences between the stability constants of strontium, barium, and radium, their separation by ion exchange [6] may be regarded as a process of complex elution, whereas the separation of magnesium and calcium as described by the authors [7] should be regarded as a process of simple ion exchange. It is also to be noted that at pH 7·2 the complex formed is mainly of the type $[MgCit]^-$, since at this pH the percentage of $[Cit^{3-}]$ ions is more than 93·7 as calculated from Bjerrum and Unmack's equations.[8]

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[4] Schubert, personal communication, 1950.
[5] Schubert, Russell, and Myers, U.S. Atomic Energy Commission AECU-542, 1949.
[6] Tompkins, *J. Amer. Chem. Soc.*, 1948, **70**, 3520.
[7] Tobia and Milad, *J. Agric. Food Chem.*, 1958, **6**, 358.
[8] Bjerrum and Unmack, *Kgl. Danske Videnskab. Selskab, Math-fys. Medd.*, 1929, **9**, 1.

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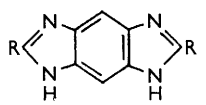
125. *The Nitration of 5-Nitro- and 2-Methyl-5-nitro-benzimidazoles.*

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

NITRATION of benzimidazole gives initially 5-nitrobenzimidazole.[1] Efros [2] has reported that further nitration of this compound gives 5,6-dinitrobenzimidazole, m. p. 186° (unsharp), the structure of which was reputedly proved by formation of benzo[1,2-*d* : 4,5-*d*']diimidazole (I; R = H) by way of the diamine. We now find that these observations of Efros are incorrect, and that nitration of 5-nitrobenzimidazole yields a mixture. The major component (54% yield) is in fact 5,6-dinitrobenzimidazole, m. p. 233°, the structure of which was proved by conversion into compound (I; R = H). The other important component (21%) proved to be the known 4,6-dinitrobenzimidazole, whose structure is established by its formation from 3,5-dinitro-1,2-phenylenediamine.[3] The m. p. diagram for mixtures of these two dinitrobenzimidazoles shows a minimum of 184° at a composition of 38% of 4,6-dinitrobenzimidazole, so that Efros's material was a mixture of approximately this composition.



(I)

By nitration of 2-methyl-5-nitrobenzimidazole Kym and Ratner [4] obtained only 2-methyl-5,6-dinitrobenzimidazole, proving its structure by conversion into the base (I; R = Me) by way of the diamine. Here also, however, some 2-methyl-4,6-dinitrobenzimidazole is formed, although the proportion is much smaller, *viz.*, 7% isolated yield (73% of the 5,6-dinitro-isomer was isolated).

The m. p.s of the dinitrobenzimidazoles prepared in the present work are compared in the following Table with the values recorded previously:

Benzimidazole	M. p.	Literature	Ref.	Benzimidazole	M. p.	Literature	Ref.
4,6-Dinitro- ...	246—246·5°	239—240°	3	2-Methyl-4,6-dinitro-	250·5—251	242°	5
5,6-Dinitro- ...	233—233·5	186	2	2-Methyl-5,6-dinitro-	230—230·5	223	4

[1] Fischer and Hess, *Ber.*, 1903, **36**, 3967; van der Want, *Rec. Trav. chim.*, 1948, **67**, 45.
[2] Efros, *Zhur. obshchei Khim.*, 1952, **22**, 1008.
[3] Bahner, Rutter, and Rives, *J. Amer. Chem. Soc.*, 1952, **74**, 3689.
[4] Kym and Ratner, *Ber.*, 1912, **45**, 3238.
[5] Nietzki and Hagenbach, *Ber.*, 1897, **30**, 539.

Experimental.—5-Nitro-, m. p. 205·5—206°, and 2-methyl-5-nitro-benzimidazole, m. p. 222—222·5°, were prepared by nitration of benzimidazole and of 2-methylbenzimidazole, respectively, by Fischer and Hess's method.[1]

Nitration of 5-nitrobenzimidazole. A solution of 5-nitrobenzimidazole (27·0 g.) in sulphuric acid (*d* 1·84; 30 ml.) was treated with nitric acid (*d* 1·50; 60 ml.) and refluxed for 2 hr., then poured on ice. A slight excess of ammonia was added, and the precipitate was collected and washed with cold water to leave, after drying, a yellow powder (31·4 g., 91%), m. p. 182—195°. Hydrogen chloride was passed into a suspension of this solid in warm water (120 ml.) until a clear yellow solution was obtained, and then with cooling in ice–water, until the liquid was saturated. The hydrochloride which had separated was collected and washed with ice-cold concentrated hydrochloric acid (50 ml.); a further small quantity of it was obtained by evaporation of the filtrate and washings to 75 ml., and resaturation with hydrogen chloride. A solution of the combined crops in warm water (200 ml.) was treated with a slight excess of aqueous ammonia and, after cooling, the precipitate was collected and washed with cold water. Crystallisation of the dried solid (18·1 g.) from ethanol (180 ml.) (charcoal) gave crystals (16·0 g.), m. p. 232—233°; pure 5,6-*dinitrobenzimidazole* formed cream-coloured plates on recrystallisation successively from acetic acid and ethanol (Found: C, 40·5; H, 2·3; N, 26·6. $C_7H_4N_4O_4$ requires C, 40·4; H, 1·9; N, 26·9%).

The final filtrate and washings from the above hydrogen chloride separation were treated with ice and a slight excess of ammonia to precipitate a solid, which was collected, washed with water, and dried (13·2 g.). Crystallisation from ethanol (650 ml.) gave crystals (6·4 g.), m. p. 245—246°, a further small crop (0·7 g.) being obtained by evaporation of the mother-liquor to 180 ml.; 4,6-dinitrobenzimidazole was obtained as colourless needles by further recrystallisation from ethanol, and was identical with a sample prepared by reaction of 3,5-dinitro-1,2-phenylenediamine with formic acid.[3]

The ethanolic mother-liquors from the second crop of 4,6-dinitrobenzimidazole were evaporated to dryness, and the residue was crystallised from acetic acid (30 ml.) to give a further quantity (2·5 g.) of almost pure 5,6-dinitrobenzimidazole, m. p. 231—232°. The total yields of 4,6- and 5,6-dinitrobenzimidazoles were 23% and 59%, respectively, of the weight of crude nitration mixture (21 and 54% based on the 5-nitrobenzimidazole used).

5,6-*Diaminobenzimidazole.* Reduction of 5,6-dinitrobenzimidazole (5·0 g.) with tin (16 g.) and concentrated hydrochloric acid (50 ml.), and treatment of the resulting stannichloride with hydrogen sulphide, as described by Efros,[2] gave 5,6-*diaminobenzimidazole dihydrochloride* (3·8 g.); this formed colourless plates, m. p. >360°, on two crystallisations from 2N-hydrochloric acid (charcoal) (Found: Cl, 31·4; N, 24·3. $C_7H_{10}Cl_2N_4,\frac{1}{2}H_2O$ requires Cl, 30·8; N, 24·35%). Treatment of an aqueous solution of this material with an excess of ammonia gave the *diamine*, colourless needles, m. p. 212—213° (from water) (Found: C, 56·5; H, 5·5; N, 37·3. $C_7H_8N_4$ requires C, 56·7; H, 5·4; N, 37·8%); this compound was reasonably stable, darkening only very slightly when left for several weeks without protection from the air and light. Efros [2] obtained the dihydrochloride, presumably heavily contaminated with 4,6-diaminobenzimidazole dihydrochloride, as brown crystals, which he stated could not be purified or converted into the base because of instability.

The dihydrochloride, refluxed with an excess of formic acid for 2 hr., gave the benzodiimidazole (I; R = H) (79%), m. p. >400° (not m. p. about 360°, as recorded by Efros; [2] Arient, Marham and Täublová [6] record m. p. >450°); the infrared spectrum was identical with that of the material prepared by reaction of benzene-1,2,4,5-tetra-amine tetrahydrochloride with formic acid.[6,7]

Nitration of 2-methyl-5-nitrobenzimidazole. This compound (30·0 g.) was nitrated as was 5-nitrobenzimidazole, and the crude product (36·7 g., 97·5%), m. p. 186—209°, was treated in water (400 ml.) with hydrogen chloride as before. The resulting hydrochloride with ammonia gave 2-methyl-5,6-dinitrobenzimidazole (27·4 g.), m. p. 228—229° (from acetic acid), which formed cream-coloured plates on further crystallisations from ethanol (Found: C, 42·8; H, 2·7. Calc. for $C_8H_6N_4O_4$: C, 43·25; H, 2·7%).

The mother-liquors from the hydrochloride were treated with ammonia, and the product was crystallised from ethanol (170 ml.) to give 2-methyl-4,6-dinitrobenzimidazole (2·8 g.), m. p. 249—250°, which formed pale yellow needles on recrystallisation from acetic acid and

[6] Arient, Marham, and Täublová, *Coll. Czech. Chem. Comm.*, 1960, **25**, 1602.
[7] Phillips, *J.*, 1930, 1409.

then ethanol. It was identical with a sample prepared by reaction of 3,5-dinitro-1,2-phenylenediamine with acetic acid.[5] The yields of the 4,6- and the 5,6-dinitro-compound were 7% and 73%, respectively, based on 2-methyl-5-nitrobenzimidazole used (8 and 75% of the crude nitration mixture).

5,6-Diamino-2-methylbenzimidazole. This was prepared by reduction of 2-methyl-5,6-dinitrobenzimidazole with tin and hydrochloric acid (cf. Kym and Ratner [4]), as colourless needles, m. p. 246—247° (decomp.) (from ethanol), and was apparently indefinitely stable in air (Found: C, 59·1; H, 6·0; N, 35·1, 34·4. Calc. for $C_8H_{10}N_4$: C, 59·2; H, 6·2; N, 34·6%). Kym and Ratner [4] describe this compound as pale brownish needles, m. p. 300°, and Efros [2] describes it as long sandy needles, oxidised rapidly in air.

The amine, when refluxed with acetic acid and dilute hydrochloric acid, gave the benzodiimidazole (I; R = Me), m. p. >400°, identical in infrared spectrum with the compound prepared by reaction of benzene-1,2,4,5-tetra-amine tetrahydrochloride with acetic acid.[5,6,8]

We thank Miss J. Connor for the microanalyses.

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[*Received, July 16th,* 1962.]

[8] Ruggli and Fischer, *Helv. Chim. Acta*, 1945, **28**, 1270.

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126. *Mercury*(II) *Complexes of* β-*Diketones.*

By D. C. NONHEBEL.

MERCURY(II) chelates of β-diketones have been known for many years and are believed to have the normal cyclic chelate structure.[1] The infrared spectra of mercury(II) complexes of acetylacetone, di-isobutyroylmethane, and dipivaloylmethane show strong absorption at 1684—1678 cm.$^{-1}$ characteristic of the αβ-unsaturated carbonyl group but no absorption in the 1650—1500 cm.$^{-1}$ region so characteristic of β-diketone chelates of other metals.[2,3] This, coupled with the insolubility of the mercury complexes of di-isobutyroylmethane and dipivaloylmethane in non-polar solvents such as benzene, light petroleum, and carbon tetrachloride (in which the chelate compounds of a wide range of metals with these diketones are very soluble), suggest that these complexes might be better represented as mercury enolates of the diketones, $Hg(O{\cdot}CR'{:}CH{\cdot}COR)_2$, rather than as cyclic chelates.

This structure is supported by the fact that mercury derivatives of di-isobutyroylmethane and dipivaloylmethane react with both benzoyl and *p*-nitrobenzoyl chloride to give predominantly the *O*-acylated β-diketone. Chelates of these two β-diketones with other metals, excepting zinc,[3,4] react with benzoyl chloride to give mainly the *C*-benzoylated diketone. The zinc chelates give predominantly the *O*-benzoylated diketone. The anomalous behaviour of the zinc chelates has been attributed to the strong Lewis-acid activity of zinc and the fact that zinc is co-ordinately satisfied in bis-chelates of β-diketones. The zinc chelates of these diketones on reaction with *p*-nitrobenzoyl chloride gave an appreciable amount of the *C*-acylated diketone (see Table); this can be rationalized on the basis that reactions with *p*-nitrobenzoyl chloride have a greater degree of S_N2 character which results in formation of more of the *C*-compound.[5] That mercury derivatives of these diketones

[1] Morgan and Moss, *J.*, 1914, **105**, 195; Sidgwick, " The Chemical Elements and their Compounds," Oxford University Press, 1950, p. 330.
[2] Bellamy and Branch, *J.*, 1954, 4491; Holtzclaw and Collman, *J. Amer. Chem. Soc.*, 1957, **79**, 3318; Nakamoto, McCarthy, and Martell, *ibid.*, 1961, **83**, 1272; West and Riley, *J. Inorg. Nuclear Chem.*, 1958, **5**, 295; Duval, Freymann, and Lecomte, *Bull. Soc. chim. France*, 1952, 106.
[3] Hammond and Nonhebel, unpublished work.
[4] Murdoch and Nonhebel, *J.*, 1962, 2153.
[5] Murdoch and Nonhebel, unpublished work.

Amounts (%) of *C*-benzoylated product in reactions of zinc and mercury chelates of di-isobutyroylmethane (H_2DIBM) and dipivaloylmethane (H_2DPM) with benzoyl and *p*-nitrobenzoyl chloride.

	$Zn(DIBM)_2$	$Hg(DIBM)_2$	$Zn(DPM)_2$	$Hg(DPM)_2$
Benzoyl chloride *	18	11	0	4
p-Nitrobenzoyl chloride †	71	0	55	10

* *C*-Compounds estimated by ultraviolet-absorption spectroscopy. † *C*-Compounds isolated from the reaction mixtures by utilizing their lower solubility.

with *p*-nitrobenzoyl chloride do not give an appreciable amount of *C*-compound is consistent with their having an acylic structure.

Experimental.—Infrared spectra were determined for Nujol mulls.

Preparation of mercury(II) *derivatives of* β-*diketones.* Mercury(II) acetylacetone was prepared from sodium acetylacetone and mercury(II) chloride as a white powder insoluble in organic solvents, and had $\nu_{max.}$ 1684 cm.$^{-1}$.

Mercury(II) *di-isobutyroylmethane* was prepared by adding an ethanol solution of the diketone to an aqueous solution of mercury(II) chloride and sodium acetate. It crystallized from acetone as a white powder, m. p. 208—210°, $\nu_{max.}$ 1684 cm.$^{-1}$ (Found: Hg, 38·8. $C_{18}H_{30}HgO_4$ requires Hg, 39·3%).

Mercury(II) *dipivaloylmethane* was similarly prepared from dipivaloylmethane and crystallized as colourless tablets, m. p. 192°, $\nu_{max.}$ 1678 cm.$^{-1}$ (Found: Hg, 35·2. $C_{22}H_{38}HgO_4$ requires Hg, 34·8%).

Preparation of zinc chelates. Zinc di-isobutyroylmethane, prepared [4] from di-isobutyroylmethane and zinc acetate, had m. p. 152°.

Zinc dipivaloylmethane was prepared by refluxing a solution of dipivaloylmethane in toluene over zinc dust for 48 hr. The solution was filtered and evaporated to dryness and the residue crystallized from light petroleum (b. p. 40—60°); it then had m. p. 142° (Found: Zn, 15·3. $C_{22}H_{38}O_4Zn$ requires Zn, 15·2%).

Reaction of mercury(II) *di-isobutyroylmethane with benzoyl chloride.* Mercury(II) di-isobutyroylmethane (0·36 g.) and benzoyl chloride (0·17 ml.) in cyclohexane (20 ml.) were refluxed for 6½ hr. The mixture was treated with pyridine containing a small amount of water to hydrolyse the excess of benzoyl chloride and was then washed successively with water, dilute hydrochloric acid, water, sodium hydrogen carbonate solution, and water. After being dried, a small portion of the solution was analyzed by ultraviolet-absorption spectroscopy (see ref. 4 for experimental procedure). The results indicated that the product contained 11·0% of benzoyldi-isobutyroylmethane, the remainder being a mixture of *O*-benzoyldi-isobutyroylmethane (5-benzoyloxy-2,6-dimethylhept-4-ene-3-one) and di-isobutyroylmethane, the latter resulting from hydrolysis of the *O*-compound. The remainder of the solution was evaporated to dryness and the residue, in light petroleum (b. p. 60—80°), was chromatographed on alumina. Light petroleum eluted *O*-benzoyldi-isobutyroylmethane (0·22 g., 60%), identified by comparison of its infrared spectrum with that of an authentic sample.

Reaction of zinc di-isobutyroylmethane with p-*nitrobenzoyl chloride.* Zinc di-isobutyroylmethane (0·94 g.) and *p*-nitrobenzoyl chloride (0·94 g.) in cyclohexane (50 ml.) were refluxed for 3 hr. The mixture was cooled and zinc chloride filtered off. The filtrate was treated as above and the residue in ethanol treated with copper acetate; copper di-isobutyroyl-*p*-nitrobenzoylmethane (1·2 g., 71%), m. p. and mixed m. p. 215—217°, was obtained and formed green prisms from methanol. Hydrolysis of the copper chelate with dilute hydrochloric acid gave di-isobutyroyl-*p*-nitrobenzoylmethane, m. p. and mixed m. p. 109—110°.

Reaction of mercury(II) *di-isobutyroylmethane with* p-*nitrobenzoyl chloride.* Mercury(II) di-isobutyroylmethane (1·00 g.) and *p*-nitrobenzoyl chloride (0·74 g.) in cyclohexane (50 ml.) were refluxed for 2·5 hr. The mixture was cooled and mercury(II) chloride filtered off. The filtrate was treated as above. Treatment of the residue with copper acetate gave no copper di-isobutyroyl-*p*-nitrobenzoylmethane, showing the absence of *C*-compound.

Reaction of zinc dipivaloylmethane with benzoyl chloride. Zinc dipivaloylmethane (0·215 g.) and benzoyl chloride (0·14 ml.) in cyclohexane (20 ml.) were refluxed for 1·5 hr. Zinc chloride was filtered off from the cooled mixture, and the filtrate treated as above. Analysis of the

residue by ultraviolet-absorption spectroscopy showed absence of benzoyldipivaloylmethane. The remainder of the residue was crystallized from light petroleum (b. p. 40—60°), affording colourless needles of *O*-benzoyldipivaloylmethane (5-benzoyloxy-2,2,6,6-tetramethylhept-4-ene-3-one), m. p. and mixed m. p. 73°.

Reaction of mercury dipivaloylmethane with benzoyl chloride. Mercury dipivaloylmethane (2·83 g.) and benzoyl chloride (1·25 ml.) in cyclohexane (150 ml.) were refluxed for 6 hr. The mixture was worked up as usual. Ultraviolet-absorption spectroscopy showed the presence of 4% of benzoyldipivaloylmethane. Crystallization of the residue from light petroleum (b. p. 40—60°) gave *O*-benzoyldipivaloylmethane.

Reaction of zinc dipivaloylmethane with p-*nitrobenzoyl chloride.* Zinc dipivaloylmethane (1·96 g.) and *p*-nitrobenzoyl chloride (1·75 g.) in cyclohexane (200 ml.) were refluxed for 2 hr. On cooling of the solution, a yellow solid separated crystallization of which from methanol gave *p*-nitrobenzoyldipivaloylmethane (1·7 g., 57%), m. p. and mixed m. p. 192°. The filtrate was treated as above, to hydrolyze the excess of acid chloride. The residue thus obtained crystallized from light petroleum (b. p. 40—60°), giving colourless needles of *O*-*p*-nitrobenzoyldipivaloylmethane (2,2,6,6-tetramethyl-5-*p*-nitrobenzoyloxyhept-4-ene-3-one) (0·55 g., 18%), m. p. and mixed m. p. 116°.

Reaction of mercury(II) *dipivaloylmethane with* p-*nitrobenzoyl chloride.* Mercury(II) dipivaloylmethane (2·83 g.) and *p*-nitrobenzoyl chloride (1·85 g.) in cyclohexane (150 ml.) were refluxed for 6 hr. The white precipitate was filtered off and washed with hot water to dissolve any mercuric chloride, leaving a residue of *p*-nitrobenzoyldipivaloylmethane (0·34 g., 10%). The filtrate gave some *O*-*p*-nitrobenzoyldipivaloylmethane.

Analysis of metal chelates. Zinc dipivaloylmethane was decomposed with 20% hydrochloric acid, the solution was extracted with ether, neutralized with sodium hydroxide, and buffered with an aqueous ammonia–ammonium chloride buffer, and the zinc was estimated by titration with disodium dihydrogen ethylenediaminetetra-acetate to Eriochrome T as indicator.

The mercury chelates were decomposed with 20% hydrochloric acid, the solution was extracted with ether, and the mercury determined as mercury sulphide.

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127. *The Stobbe Condensation. Part III.*[1] *The Cyclisation of Ethyl Hydrogen γ-*p*-Tolyl-, and Ethyl Hydrogen γ-*p*-Chlorophenyl-itaconate to the Corresponding Naphthalene Derivatives.*

By LANSON S. EL-ASSAL, (MRS.) SAMIHA M. A. EL-WAHHAB, and (MISS) NARGUES S. BACEILI.

PREVIOUSLY [1,2] it was shown that the Stobbe condensation of aromatic aldehydes having electron-repelling substituents gave the corresponding β-half-esters which were then easily cyclised to the corresponding naphthalene derivatives. Therefore, the aims of this investigation were to prepare β-half-esters having either a weak electron-repelling (methyl) or an electron-attracting group (chloro), in order to study the effect of the polar nature of the substituents on the mode of cyclisation.

Thus, heating the substituted benzaldehydes (substituents: *p*-methyl, *p*- and *o*-chloro) with ethyl succinate in the presence of potassium t-butoxide in t-butyl alcohol [1] gave β-ethyl α-hydrogen *cis*/*trans*-γ-*p*-tolyl-, -*p*-chlorophenyl-, and -*o*-chlorophenyl-itaconate, in about 75—80% yield, together with αβ-di-*p*-tolylidene-[3] αβ-di-*p*-chlorobenzylidene-[4] (*ca.* 18%),[5] and αβ-di-*o*-chlorobenzylidene-succinic acid [6] (*ca.* 16%), respectively. A

[1] Part II, El-Assal and El-Wahhab, *J.*, 1960, 849.
[2] El-Abbady and El-Assal, *J.*, 1959, 1024.
[3] Baddar, El-Assal, and Gindy, *J.*, 1948, 1270.
[4] Baddar, El-Assal, Doss, and Shehab, *J.*, 1959, 1016.
[5] El-Assal and El-Wahhab, *J. Chem.* (*U.A.R.*), in the press.
[6] Baddar, El-Assal, and Doss, *J.*, 1955, 461.

mechanism explaining the formation of these succinic acids was recently suggested by El-Assal and El-Wahhab.[5] From the chlorobenzaldehydes, we were also able to isolate the corresponding *o*- and *p*-chlorobenzoic acids, arising by a Cannizzaro reaction.

The crude mixtures of β-half-ester stereoisomers were cyclised [1] to acetoxy-2-naphthoates in nearly quantitative yield. Alkaline hydrolysis then gave 4-hydroxy-6-methyl- and 4-hydroxy-6-chloro-2-naphthoic acid. These were methylated to methyl 4-methoxy-6-methyl- and 6-chloro-4-methoxy-2-naphthoate, which on hydrolysis gave the corresponding naphthoic acids; decarboxylation of the corresponding free acids with copper-bronze in quinoline then gave 1-methoxy-7-methyl- and 7-chloro-1-methoxy-naphthalene.

Hydrolysis of the crude β-half-esters gave β-*p*-tolyl- and γ-*p*-chlorophenyl-itaconic acid, whose anhydrides were esterified by boiling methanol to the α-half-esters. These α-half-esters could not be the *trans*-isomers since they were unaffected by 15 days' direct sunlight (June in Cairo), or by ultraviolet irradiation (mercury-vapour quartz lamp) for 12—15 hours.[1]

Experimental.—β-*Ethyl* α-*hydrogen* cis/trans-γ-p-*tolylitaconate.*—*p*-Tolualdehyde (12 g., 1 mol.), ethyl succinate (17·5 g., 1·2 mol.), and potassium t-butoxide [from potassium (5·8 g.)] were treated as previously described.[2] The product (*ca.* 19 g.) was extracted with boiling benzene, and insoluble material filtered off. Removal of benzene gave a liquid mixture (*ca.* 18 g.) of β-ethyl α-hydrogen γ-p-tolylitaconate (I*a*) stereoisomers which failed to crystallise and was used directly in the following experiment.

The benzene-insoluble product (*ca.* 0·8 g.) was treated with hot dilute hydrochloric acid for several minutes, and the insoluble product was filtered off and dried to give αβ-di-*p*-tolylidenesuccinic acid [3] (from 70% acetic acid), m. p. and mixed m. p. 219—220°.

Replacing the ethyl by the methyl ester in the above Stobbe condensation also gave an uncrystallisable mixture of stereoisomers.

Ethyl 4-*acetoxy*-6-*methyl*-2-*naphthoate.* The crude mixture of β-half-esters (I*a*) (2·5 g.) was cyclised with sodium acetate (1·6 g.) in acetic anhydride (24 ml.).[2] The product (*ca.* 2·6 g.) was crystallised from benzene–light petroleum (b. p. 60—80°), giving *ethyl* 4-*acetoxy*-6-*methyl*-2-*naphthoate*, m. p. 118—119° (Found: C, 71·0; H, 6·1; OEt, 15·0. $C_{16}H_{16}O_4$ requires C, 70·6; H, 5·9; OEt, 16·5%).

Methyl 4-*acetoxy*-6-*methyl*-2-*naphthoate* was prepared as above and had m. p. 130—131° (Found: C, 69·8; H, 5·8; OMe, 12·0. $C_{15}H_{14}O_4$ requires C, 69·75; H, 5·45; OMe, 12·0%).

Both esters were hydrolysed to the same 4-hydroxy-6-methyl-2-naphthoic acid, m. p. 262—264°, which decomposed during purification from glacial acetic acid.

Methyl 4-*methoxy*-6-*methyl*-2-*naphthoate.* The preceding acid (2 g.) with dimethyl sulphate (6 g.) and potassium carbonate (10 g.) in acetone (60 ml.) (10 hours' refluxing) gave *methyl* 4-*methoxy*-6-*methyl*-2-*naphthoate* (*ca.* 2·1 g.) as pale brown rosettes, m. p. 110—111° (from methanol) (Found: C, 73·4; H, 6·3; OMe, 26·1. $C_{14}H_{14}O_3$ requires C, 73·0; H, 6·1; 2OMe, 26·95%). Hydrolysis gave 4-*methoxy*-6-*methyl*-2-*naphthoic acid*, m. p. 235—236° (Found: C, 72·2; H, 5·45; OMe, 14·6. $C_{13}H_{12}O_3$ requires C, 72·2; H, 5·6; OMe, 14·35%).

1-*Methoxy*-7-*methylnaphthalene.* A solution of the above methoxy-acid (0·8 g.) in quinoline (15 ml.) was gradually heated to the boiling point with copper-bronze (1·2 g.) during 30 min., then an equal amount of copper-bronze was added in portions to the boiling solution during 1 hr.; the whole was then refluxed for a further hour, and worked up as usual. The product (0·5 g.) was crystallised from light petroleum (b. p. <40°), giving 1-*methoxy*-7-*methylnaphthalene*, m. p. 65—66° (Found: C, 83·9; H, 6·9; OMe, 17·5. $C_{12}H_{12}O$ requires C, 83·7; H, 7·0; OMe, 18·0%).

By a similar sequence of reactions the following compounds were prepared: Stobbe condensation of *p*-chlorobenzaldehyde and ethyl succinate gave αβ-di-*p*-chlorobenzylidenesuccinic acid,[4] m. p. and mixed m. p. 225—226° (and some *p*-chlorobenzoic acid, m. p. 234—235°), and β-ethyl α-hydrogen *cis/trans*-γ-*p*-chlorophenylitaconate, which failed to crystallise (as did the corresponding methyl half-ester). Cyclisation of the ethyl half-ester mixture gave *ethyl* 4-*acetoxy*-6-*chloro*-2-*naphthoate*, pale yellow crystals, m. p. 119—120° (from benzene–light petroleum) (Found: C, 61·2; H, 4·6; Cl, 10·9; OEt, 15·1. $C_{15}H_{13}O_4Cl$ requires C, 61·5; H, 4·45; Cl, 12·1; OEt, 15·4%). *Methyl* 4-*acetoxy*-6-*chloro*-2-*naphthoate* formed pale yellow

crystals (from benzene–light petroleum), m. p. 125—126° (Found: C, 59·65; H, 3·9; Cl, 12·5; OMe, 10·75. $C_{14}H_{11}O_4Cl$ requires C, 60·3; H, 3·9; Cl, 12·7; OMe, 11·2%). Both esters were hydrolysed to 6-chloro-4-hydroxy-2-naphthoic acid, m. p. 192—195°, which decomposed on repeated crystallisation from acetic acid. The chloro-hydroxynaphthoic acid was then methylated to give *methyl 6-chloro-4-methoxy-2-naphthoate*, needles (from benzene), m. p. 130—131° (Found: C, 61·9; H, 4·25; Cl, 14·5; OMe, 24·3. $C_{13}H_{11}O_3Cl$ requires C, 62·3; H, 4·4; Cl, 14·2; 2OMe, 24·75%), which was hydrolysed to *6-chloro-4-methoxy-2-naphthoic acid*, needles, m. p. 287—288° (Found: C, 61·2; H, 3·8; Cl, 15·3; OMe, 13·0. $C_{12}H_9O_3Cl$ requires C, 60·9; H, 3·8; Cl, 15·0; OMe, 13·1%). When the chloro-methoxy-acid was decarboxylated, 7-chloro-1-methoxynaphthalene was obtained as an oil. When heated in tetralin (0·5 ml.) with 10% palladised charcoal (0·02 g.) at 205—210° for 4 hr.[8] 7-chloro-1-methoxynaphthalene (0·3 g.) gave 1-methoxynaphthalene, which was nitrated [7] to 1-methoxy-4-nitronaphthalene, yellow crystals, m. p. and mixed [7] m. p. 84—85°.

γ-p-*Tolylitaconic acid. Method* (*i*). The mixture of stereoisomeric β-half-esters (I*a*) (6·2 g.) was hydrolysed with concentrated aqueous barium hydroxide solution (150 ml.) (8 hours' refluxing), and the precipitate treated as usual.[1,2] The liberated acid, m. p. 168—172°, was digested with boiling benzene and the extract filtered. The product, precipitated on concentration, was repeatedly crystallised from benzene or dilute acetic acid to give *γ-p*-tolylitaconic acid, m. p. 178—179° (Found: C, 65·1; H, 5·6. Calc. for $C_{12}H_{12}O_4$: C, 65·45; H, 5·45%).

Method (*ii*). A mixture of *p*-tolualdehyde (12 g., 1 mol.), diethyl succinate (17·5 g., 1·2 mol.), and metallic sodium (5·5 g., 1·2 mol.) in ethanol (150 ml.) was refluxed for 3 hr. Alcohol was then removed, 5% sodium hydroxide solution (400 ml.) was added, and the solution was refluxed for 20 min. and cooled. The insoluble product was extracted with benzene, and the clear cold alkaline solution (charcoal) was acidified. The precipitated acid was washed with hot water, dried, and crystallised from benzene or dilute acetic acid, giving *γ-p*-tolylitaconic acid, m. p. and mixed m. p. 178—179°.

γ-p-*Tolylitaconic anhydride*. The above acid (0·75 g.) was boiled with acetyl chloride (10 ml.) for 4 hr. The anhydride formed faint brown crystals (*ca.* 0·65 g.), m. p. 160—161° (from benzene) (Found: C, 72·2; H, 4·9. Calc. for $C_{12}H_{10}O_3$: C, 71·8; H, 4·95%).

α-Ethyl β-hydrogen cis-*γ*-p-*tolylitaconate*. The anhydride (0·1 g.) was refluxed in ethanol (10 ml.) for 4 hr. Evaporation and crystallisation of the residue (*ca.* 0·1 g.) from light petroleum (b. p. 30—50°) gave *α-ethyl β-hydrogen* cis-*γ*-p-*tolylitaconate* as pale yellow needles, m. p. 106—107° (Found: C, 67·7; H, 6·45; OEt, 17·9. $C_{14}H_{16}O_4$ requires C, 67·7; H, 6·45; OEt, 18·1%).

γ-p-*Chlorophenylitaconic acid*. The mixture of β-half-esters (*ca.* 6·5 g.) was refluxed with 15% aqueous-alcoholic (v/v) potassium hydroxide solution (50 ml.) for 4 hr. The alcohol was evaporated, and the residual solution (charcoal) was acidified. The precipitate was washed, dried (*ca.* 6 g.), extracted with boiling benzene, and filtered from precipitated αβ-di-*p*-chlorobenzylidenesuccinic acid (*ca.* 1·3 g.), m. p. and mixed m. p. 225—226°.

The benzene solution was evaporated, and the residue extracted several times with boiling water. Filtration, concentration, and cooling gave *γ-p*-chlorophenylitaconic acid (from water), m. p. 195—196° (Found: C, 54·3; H, 3·7; Cl, 14·7. Calc. for $C_{11}H_9O_4Cl$: C, 54·9; H, 3·7; Cl, 14·7%).

γ-p-*Chlorophenylitaconic anhydride*. The acid (0·5 g.) and acetyl chloride (5 ml.) (5 hours' refluxing) gave the anhydride (*ca.* 0·35 g.) (from benzene), m. p. 167—168° (Found: C, 59·3; H, 2·95; Cl, 15·5. Calc. for $C_{11}H_7O_3Cl$: C, 59·3; H, 3·1; Cl, 15·95%).

α-Methyl β-hydrogen cis-*γ*-p-*chlorophenylitaconate*. The anhydride (*ca.* 0·25 g.) in methanol (50 ml.) gave *α-methyl β-hydrogen* cis-*γ*-p-*chlorophenylitaconate* (*ca.* 0·2 g.), m. p. 136—137°) [from benzene–light petroleum (b. p. 30—50°)] (Found: C, 56·6; H, 4·3; Cl, 14·1; OMe, 12·6. $C_{12}H_{11}O_4Cl$ requires C, 56·6; H, 4·3; Cl, 13·9; OMe, 12·1%).

The Stobbe condensation of o-*chlorobenzaldehyde with dimethyl succinate*. Condensation of *o*-chlorobenzaldehyde (14·1 g., 1 mol.) and methyl succinate (17·5 g., 1·2 mol.) in t-butyl alcohol in presence of potassium t-butoxide gave αβ-di-*o*-chlorobenzylidenesuccinic acid,[6] m. p. and mixed m. p. 233—234° (*ca.* 2 g.), *o*-chlorobenzoic acid, m. p. and mixed m. p. 138—139°, and a viscous dark brown oil (possibly β-methyl α-hydrogen *cis/trans-γ-o*-chlorophenylitaconate).

[7] Baddar, El-Assal, and Baghos, *J.*, 1958, 986.
[8] Doss, unpublished work.

The oil failed to crystallise and its cyclisation with sodium acetate in acetic anhydride gave abnormal results.

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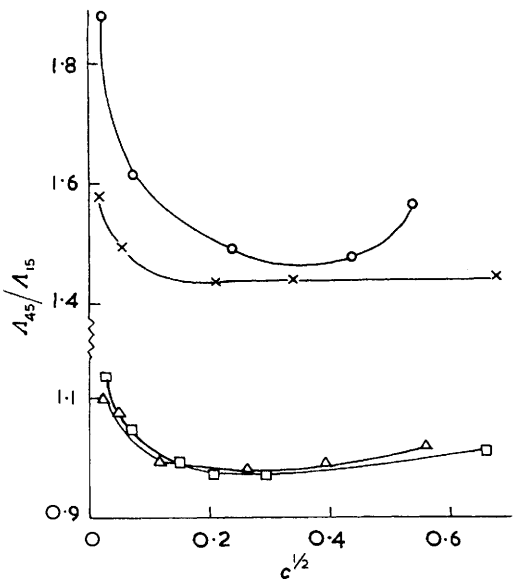
A'IN-SHAMS UNIVERSITY, CAIRO, EGYPT, U.A.R. [*Received, August 8th*, 1961.]

128. *The Temperature Coefficient of Conductance.*

By P. T. ARMITAGE and [the late] C. M. FRENCH.

THE temperature coefficient of electrical conductance is normally considered to be small and positive for inorganic salts in both water and non-aqueous solvents; and for organic salts such as quaternary ammonium compounds in various organic media. Few exceptions to this generally obeyed rule are to be found in the literature, notable examples being



Ratio of the equivalent conductance copper perchlorate dihydrate at 45° to that at 15° plotted against concentration.
× Ethanol. ○ n-Butanol. △ Ethyl methyl ketone. □ Methyl n-propyl ketone.

solutions in liquid sulphur dioxide of sodium iodide, potassium iodide, and tetramethylammonium iodide [1] (where a positive temperature coefficient was found at high and at low concentrations, and a negative one at intermediate ranges), and solutions of potassium iodide in acetonitrile.[2]

A negative temperature coefficient of conductance is now reported for solutions of cupric perchlorate dihydrate in ethyl methyl ketone (dielectric constant, $\varepsilon_{20} = 18{\cdot}5$) and in methyl n-propyl ketone ($\varepsilon_{25} = 16{\cdot}4$), over certain ranges of concentration. Also, in these solutions and in ethanol ($\varepsilon_{20} = 25{\cdot}7$) and n-butanol ($\varepsilon_{25} = 17{\cdot}8$) solutions of the same salt, the ratio of the equivalent conductance at 45° to that at 15° passes through a minimum at a certain concentration, as shown in the Figure. It is suggested that these phenomena may be of more general occurrence than has hitherto been assumed.

Falkenhagen,[3] in an attempt to analyse the variation of conductance with temperature, differentiates the Onsager conductance equation with respect to temperature, and obtains

[1] Franklin, *J. Phys. Chem.*, 1911, **15**, 675.
[2] Koch, *J.*, 1927, 649.
[3] Falkenhagen, "Electrolytes," Clarendon Press, Oxford, 1934, p. 201.

an expression for the equivalent conductance which is the difference between two terms, one increasing with temperature owing to decrease in viscosity, and the other containing the square root of concentration and the reciprocal of the dielectric constant of the solvent, also increasing since dielectric constants decrease with rise in temperature. Falkenhagen suggests that the observed equivalent conductance will therefore pass through a maximum at a certain temperature which will be lower for lower dielectric constants and higher concentrations. Therefore, at a given concentration the equivalent conductance at a lower temperature may be equal to that at a higher temperature, and thereafter at all higher concentrations the equivalent conductance at the lower temperature will be the greater of the two. Thus, over this range of concentration there would be a reversal of the sign of the temperature coefficient of conductance from positive to negative, but no minimum. However, the presence of the solute will itself affect the dielectric constant of the medium, and it seems possible that the point may be reached in a given system when the effect of an increase in effective dielectric constant from this cause outweighs the effect of increased concentration in the second term of Falkenhagen's differential expression. The equivalent conductance at the higher temperature might then again increase relative to that at the lower temperature for this and higher concentrations. There would then be a minimum in the curve of the ratio of the equivalent conductances at the higher and the lower temperature against some function of concentration.

Experimental.—Cupric perchorate dihydrate was prepared by the action of perchloric acid on cupric carbonate. The resulting cupric perchlorate was dried to the dihydrate *in vacuo* at 100°.

Both ketones were purified by drying ($MgSO_4$), distilling through a Stedman column maintaining a drop ratio of 20 : 1 (ethyl methyl ketone) or 8 : 1 (methyl n-propyl ketone), and finally twice redistilling, the constant-boiling middle fractions being collected.

Conductances were measured by using a Gambrell, Leeds, and Northrup type a.c. conductance bridge with Wagner earthing, and an audio-frequency oscillator. The temperature of conductance cells containing the solutions was maintained to within $\pm 0{\cdot}01°$ in an oil thermostat.

One of the authors (P. T. A.) thanks William Bate and Son Ltd. for a maintenance grant.

QUEEN MARY COLLEGE, MILE END ROAD, LONDON, E.1. [*Received, July 18th,* 1962.]

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129. *The Isolation and Identification of Hederagenin from Ackee,* Blighia sapida *Koenig* (*Sapindaceae*).

By L. J. HAYNES, J. R. PLIMMER, and W. M. SUE-HO.

THE ackee (*Blighia sapida* Koenig) is a tropical fruit which was introduced into the Caribbean area from West Africa. In Jamaica the fleshy aril of the fruit is eaten but little is consumed elsewhere. An extensive literature deals with the connexion between ackee-eating and vomiting sickness. Studies on the arils have shown the presence of a toxic amino-acid, hypoglycine, and a related peptide.[1]

Evans and Arnold [2] considered that a saponin present in ackee was responsible for its toxicity although later workers found that extracts of ackee arils produced no hæmolysis of rabbit's blood.[3] Isolation of the saponin (1·5—2% yield) from husks of ackee, and identification of the sapogenin as hederagenin form the subject of this Note.

[1] Hassall, Reyle, and Feng, *Nature,* 1954, **173**, 356; Wilkinson, *Chem. and Ind.,* 1958, 17; Ellington, Hassall, and Plimmer, *Chem. and Ind.,* 1958, 329; Anderson, Johnson, Nelson, Olson, Speeter, and Varba, *Chem. and Ind.,* 1958, 330; Hassall and John, *Tetrahedron Letters,* 1959, No. 1, 7.

[2] Evans and Arnold, *Trans. Roy. Soc. Trop. Med. Hyg.,* 1938, **32**, 355.

[3] Larson, Wynn, Lynch, and Doughty, *Quart. J. Florida. Acad. Sci.,* 1953, **16**, 151.

Experimental.—The values of $[\alpha]_D$ refer to solutions in chloroform unless otherwise stated.

Isolation of the sapogenin. Chopped fresh husks of ripe ackees (2·2 kg.) were boiled with water (8 l.). The aqueous extract was filtered and the residue boiled with more water (6 l.). The combined filtered extracts were boiled with concentrated hydrochloric acid (1·5 l.) for 1 hr. Solid was collected by filtration, washed, and dried in the oven. The crude sapogenin (32 g.) was crystallised from methanol (charcoal), and converted into the diacetate which crystallised from methanol and on hydrolysis, followed by crystallisation from methanol, afforded hederagenin as prisms, m. p. 325°, $[\alpha]_D^{28}$ +82° (*c* 0·97 in pyridine) {lit.,[4] 325° to 332—333°, $[\alpha]_D^{20}$ +79° to 80° (in pyridine)} (Found: C, 76·3; H, 10·2; O, 13·7. Calc. for $C_{30}H_{48}O_4$: C, 76·2; H, 10·2; O, 13·5%).

The diacetate (boiling acetic anhydride–pyridine; 3 hr.) crystallised from methanol as needles, m. p. 168—170°, $[\alpha]_D^{28}$ +78° (*c* 1·1), +66·2° (*c* 0·336 in 95% ethanol) {lit.,[4] m. p. 172—174°, 173—174° (sinters 156°), $[\alpha]_D^{20}$ +64° (*c* 0·312 in ethanol), $[\alpha]_D$ +80·7° (*c* 2·86)} (Found: C, 73·5; H, 9·3; O, 17·4. Calc. for $C_{34}H_{52}O_6$: C, 73·3; H, 9·4; O, 17·2%).

The methyl ester, obtained by diazomethane in methanol–ether, recrystallised from acetone; when sublimed it had m. p. and mixed m. p. 236—237°, $[\alpha]_D^{28}$ +71·7° (*c* 0·98) {lit.,[4,5] m. p. 236—237°, 240°, $[\alpha]_D^{20}$ +75° (*c* 1·0 in ethanol), $[\alpha]_D^{15}$ +70·9° (*c* 5·09)} (Found: C, 76·4; H, 10·5; O, 13·25. Calc. for $C_{31}H_{50}O_4$: C, 76·5; H, 10·4; O, 13·2%).

The methyl ester diacetate, prepared by treatment of the diacetate with diazomethane and crystallised from methanol, had m. p. 193°, $[\alpha]_D^{28}$ +78° (*c* 1·15) {lit.,[4] m. p. 192—193°, $[\alpha]_D^{20}$ +63° (*c* 0·564 in ethanol), $[\alpha]_D^{23}$ +76°} (Found: C, 73·7; H, 9·6; O, 16·9. Calc. for $C_{35}H_{54}O_6$: C, 73·6; H, 9·5; O, 16·8%).

The lactone diacetate was prepared by treatment of the sapogenin diacetate with hydrogen bromide in acetic acid [6] and, recrystallised from ethanol, had m. p. 249°, $[\alpha]_D^{28}$ +31·6° (*c* 1·6) (lit.,[6,7] m. p. 235°,[6] m. p. 248—248·5°) (Found: C, 73·7; H, 9·5; O, 17·3. Calc. for $C_{34}H_{52}O_6$: C, 73·3; H, 9·4; O, 17·2%).

The lactone diacetate was converted into the lactone by alkali. When purified by sublimation this had m. p. 347°, $[\alpha]_D^{28}$ +29° (*c* 1·19 in pyridine) (lit.,[6] 354°).

The research was supported by the Tropical Products Institute, London, in their Natural Products Research Unit of which one of us (J. R. P.) is a Research Fellow and another a research student (W. M. S.). We thank Professor D. H. R. Barton for an authentic sample of hederagenin methyl ester.

T.P.I. Natural Products Research Unit, Chemistry Dept.,
University of the West Indies, Kingston 7,
Jamaica, West Indies. [*Received, July 23rd*, 1962]

[4] McShefferty and Stenlake, *J.*, 1956, 2314; Jacobs, *J. Biol. Chem.*, 1925, **63**, 621; Kutani and Kau, *J. Pharm. Soc. Japan*, 1944, **64**, 18.
[5] Van den Haar and Tamburello, *Ber.*, 1921, **54**, 3148.
[6] Winterstein and Wiegand, *Z. physiol. Chem.*, 1931, **199**, 46.
[7] Ruzicka, Norymberski, and Jeger, *Helv. Chim. Acta*, 1943, **26**, 2242.

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130. *Solasonine from* Solanum verbascifolium *L.*

By L. J. Haynes and C. E. Seaforth.

A hypotensive base has been isolated from *Solanum verbascifolium* L. and identified as solasonine (0·03% of leaves and green stems of plant). "Traces of solanine" were obtained from *S. verbascifolium* L. by Payen and Chevalier.[1] Solasonine has been obtained [2,3] also from other *Solanum* species.

Experimental.—Ground dried leaves and green stems of the plant (1·8 kg.) were percolated with 1% aqueous tartaric acid (8 l.). The extract was concentrated *in vacuo*, then filtered

[1] Payen and Chevalier, *J. Chim. Med.*, 1825, **1**, 517 (see Wehmer, "Die Pflanzenstoffe," Gustav Fischer Verlag, Jena, 2nd Edition, 1931, Vol. II, p. 1092).
[2] Briggs and Cambie, *J.*, 1958, 1422.
[3] Bianchi, Diaz, Charlin, and Garbarino, *Atti Accad. naz. Lincei. Rend. Classe Sci. fis. mat. nat.*, 1960, **11**, 465.

and washed with ether, the washings being discarded. The aqueous solution was heated and brought to pH 10 with concentrated aqueous ammonia, the precipitate was collected, dissolved in hydrochloric acid, and reprecipitated with ammonia (material A). The bulked alkaline aqueous filtrates were extracted with chloroform and then discarded. The chloroform extract was dried (Na_2SO_4) and evaporated to yield non-alkaloidal material (1·6 g.). The reprecipitated bases A (1·3 g.) gave positive tests with Mayer's, Wagner's, and Kraut's reagent and the platinum chloride–potassium iodide spray.

These bases were chromatographed twice on alumina (activity IV; 10 × 2 cm.; prepared in chloroform) with 1 : 1 methanol–water as eluant. The product (0·65 g.) gave a single spot at R_F 0·7 when chromatographed on Whatman No. 1 paper with butan-1-ol–acetic acid–water (10 : 3 : 8) and crystallised from 3 : 7 methanol–water as plates, m. p. 269—271° (decomp.), $[\alpha]_D^{25}$ −66·6° (*c* 0·21 in MeOH) (Found: C, 60·7; H, 8·0; N, 1·4. Calc. for $C_{45}H_{73}O_{16}N,\frac{1}{2}H_2O$: C, 60·6; H, 8·4; N, 1·6%) [lit.,[4] m. p. 284—285° (decomp.), $[\alpha]_D^{25}$ −68·7°, (*c* 0·2 in MeOH)]. Its picrate was obtained as needles, m. p. 198° (decomp.) (lit.,[2] m. p. 197—199° (decomp.)]. It did not depress the m. p. of an authentic sample of solasonine, and gave an infrared absorption spectrum in Nujol mull identical with that of solasonine.

Our glucoalkaloid was hydrolysed [5] with acid. The precipitated solasodine crystallised from methanol as plates, m. p. and mixed m. p. 194—196°, $[\alpha]_D^{25}$ −95·4° (*c* = 0·11 in MeOH) (Found: C, 78·15; H, 10·4; N, 3·5. Calc. for $C_{27}H_{43}O_2N$: C, 78·45; H, 10·4; N, 3·4%) [lit.,[4] m. p. 197—198·5°, $[\alpha]_D^{25}$ −97·1° (*c* 0·14 in MeOH)], having the correct infrared spectrum as Nujol mull. The hydrolysis products remaining in concentrated aqueous solution were identified by paper chromatography on Whatman No. 1 paper with butan-1-ol–acetic acid–water (4 : 1 : 5) as galactose, glucose, and rhamnose, R_F 0·30, 0·35, and 0·54, respectively.

The research was supported by the Tropical Products Institute, London, in their Natural Products Research Unit of which one of us (C. E. S.) is a Junior Research Fellow. We are grateful to Professor L. H. Briggs, Chemistry Department, University of Auckland, New Zealand, for samples of solasodine and solasonine.

Natural Products Research Unit, Chemistry Department,
University of the West Indies,
Jamaica, West Indies.

[*Received, July 23rd,* 1962.]

[4] Bell and Briggs, *J.*, 1942, 1.
[5] Briggs and Brooker, *J.*, 1958, 1419.

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131. *The Reaction of Methylene with Tetrafluoroethylene.*

By Barbara A. Grzybowska, J. H. Knox, and A. F. Trotman-Dickenson.

The reaction of methylene with tetrafluoroethylene has been studied over a pressure range of 10—470 cm. at 20°.

Methylene was produced by photolysis of keten by light from a 125-w medium-pressure mercury lamp filtered through the Pyrex glass of the reaction vessel. Tetrafluoroethylene was kindly supplied by Imperial Chemical Industries Limited. The apparatus was similar to that previously described [1] except that experiments with total reactant pressures above 1 atm. were carried out in 3-ml. sealed ampoules. The reaction mixture contained about 10% of keten and 90% of tetrafluoroethylene. Gas-chromatography on three different stationary phases showed that only two products, A and B, were formed. The columns were 6·5 m. of 5% squalane on Celite at 0°, 5 m. of 10% acetonylacetone on Celite, and 2·5 m. of 1% dinonyl phthalate on activated alumina at 0°. The last was used for quantitative analysis. Detection was by katharometer; the carrier gas was hydrogen.

The ratio of the two products A/B depended upon the total pressure in the sense that the yield of the product with the larger retention volume, B, increased with increased pressure. By analogy with other reactions of methylene and olefins the first chromatographic peak, A, was identified as a tetrafluoropropene and the second, B, as a tetrafluorocyclopropane. This

[1] Grzybowska, Knox, and Trotman-Dickenson, *J.*, 1961, 4402.

identification is supported by the order of the retention times. The infrared spectra of the two substances between 3000 and 800 cm.$^{-1}$ were as follows:

A: 3060w, 2660w, 2600w, 2360w, 2240w, 1960w, 1860w, 1750vs, 1625s, 1375s, 1275vvs, 965s, 945s, 925s, 825s, 810s, 790s.

B: 1367w, 1273s, 1115w, 1020w, 865s.

Although no infrared spectra have been published of the relevant compounds of formula $C_3H_2F_4$ our identification on the basis of mechanism is not in disagreement with the above spectra.

The expected mechanism for the reaction is as shown.

Insertion: $CH_2 + CF_2{:}CF_2 = CF_2{:}CF{\cdot}CH_2F$ (1)

Addition: $CH_2 + CF_2{:}CF_2 = \overline{CF_2{\cdot}CH_2{\cdot}CF_2}^{*}$ (2)

Deactivation: $\overline{CF_2{\cdot}CH_2{\cdot}CF_2}^{*} + M = \overline{CF_2{\cdot}CH_2{\cdot}CF_2} + M$ (3)

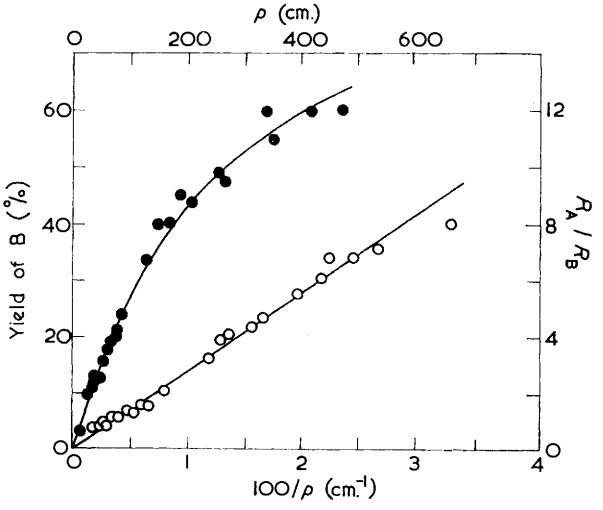
Isomerisation: $\overline{CF_2{\cdot}CH_2{\cdot}CF_2}^{*} = \left\{ \begin{array}{l} CF_2{:}CH{\cdot}CHF_2 \\ CH_2{:}CF{\cdot}CF_2 \\ CF_2{:}CF{\cdot}CH_2F \end{array} \right\}$ (4)

This reaction scheme gives for the relative product yields

$$R_p/R_\Delta = k_1/k_2 + (k_4/k_3p)(1 + k_1/k_2)$$

where R_p and R_Δ are the fractional yields of the tetrafluoropropenes and of the tetrafluorocyclopropane, and p is the total pressure representing the concentration of the deactivating species in reaction (3). A plot of R_p/R_Δ against p^{-1} should therefore be a straight line with intercept (k_1/k_2) and gradient k_4/k_3.

The pressure-dependence of the yields of A and B agrees with this relation (Figure) and the intercept is zero. This indicates that $k_1 = 0$ and that within experimental error the insertion of methylene into the C–F bond does not occur (*i.e.*, less than about 5%).



The dependence of the yield of B (tetrafluorocyclopropane) on pressure (full circles, upper and left-hand scales) and of the ratio of A : B (tetrafluoropropene : tetrafluorocyclopropane) on reciprocal pressure (open circles, lower and right-hand scales).

Since only two peaks were observed in the gas-chromatograms even on columns containing widely different stationary phases it is highly probable that only two products

were formed. The infrared spectrum of compound A suggests that it is 1,1,3,3-tetrafluoropropene rather than either of the two isomers. This indicates that migration of hydrogen during isomerisation is much faster than that of fluorine.

The ratio k_4/k_3 is 3·6 atm. and about three times the corresponding ratio for the addition of methylene to ethylene (1·19 atm.).[2] The replacement of four hydrogen atoms by fluorine should result in the increase of the number of effective Kassel oscillators in the molecule. Thus the dependence of the unimolecular rate constant on pressure for the decomposition of azomethane corresponds to the presence of 12 oscillators,[3] whereas that for the decomposition of hexafluoroazomethane corresponds to about 23.[4] Probably neither of these estimates is very accurate [5] but the trend is unmistakable. Our results can best be explained on the assumption that fluorine substitution has two effects: it increases the number of effective oscillators and increases the reactivity of the cyclopropane. The second effect predominates.

CHEMISTRY DEPARTMENT, EDINBURGH UNIVERSITY. [*Received, July 25th,* 1962.]

[2] Frey and Kistiakowsky, *J. Amer. Chem. Soc.*, 1957, **79**, 6373.
[3] Willbanks, "Evaluation of the Kassel Integral via IBM 704," Office of Technical Services, U.S. Dept. of Commerce, Washington, D.C., 1958.
[4] Leventhal, Simonds, and Steel, *Canad. J. Chem.*, 1962, **40**, 930.
[5] Steel and Trotman-Dickenson, *J.*, 1959, 975.

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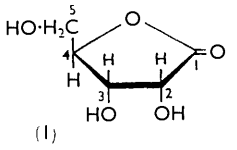
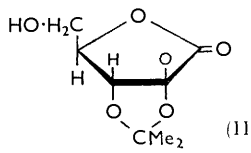
132. *A Proton Resonance Study of the Conformations of Carbohydrates in Solution. Part III.** D-*Ribono*-1→4-*lactone and its* 2,3-O-*Isopropylidene Derivative.*

By R. J. ABRAHAM, L. D. HALL, L. HOUGH, K. A. MCLAUCHLAN, and H. J. MILLER.

THE optical rotation of 2,3-*O*-isopropylidene-D-ribono-1→4-lactone (II), $[\alpha]_D$ −80°, is considerably different [1] from that of the parent lactone (I), $[\alpha]_D$ +43°. This was attributed [1] to a change in the conformation of the γ-lactone ring by the superimposition of a *cis*-fused *O*-isopropylidene ring. However, recent investigations [2] have shown that the addition of such a ring system only slightly modifies the conformation of a furanose or pyranose ring. To clarify this anomaly the proton magnetic resonance (P.M.R.) and optical rotatory dispersion (O.R.D.) spectra of (I) and (II) have been investigated.



(I)



(II)

The τ-values of $H_{(2)}$, $H_{(3)}$, $H_{(4)}$, and $H_{(5)}$ in (I) are 5·34, 5·59, 5·68, and 6·15, and in (II) 5·23, 5·29, 5·40, and 6·16, respectively. The approximate agreement between these sets of figures suggests that these molecules exist in similar conformations. This was confirmed by the similarity of the proton coupling constants (J) in the two compounds, namely: in (I), $J_{2,3}$ 5·5, $J_{3,4}$ <0·5, $J_{4,5}$ 3·3, and $J_{5,OH}$ 4·9 c./sec.; in (II), 5·5, <0·5, 2·3, and 5·0 c./sec., respectively. Such vicinal coupling constants are known to be sensitive to the precise conformations of cyclic compounds.[3] Application of the Karplus theory [4] to these

* Part II, *Chem. and Ind.*, 1962, 1465.

[1] Hough, Jones, and Mitchell, *Canad. J. Chem.*, 1958, **36**, 1720.
[2] Abraham, Hall, Hough, and McLauchlan, *Chem. and Ind.*, 1962, 213; Abraham, Hall, Hough, and McLauchlan, *J.*, 1962, 3699; Hall, Hough, McLauchlan, and Pachler, *Chem. and Ind.*, 1962, 465.
[3] Conroy, *Advances in Organic Chemistry*, 1960, **2**, 265.
[4] Karplus, *J. Chem. Phys.*, 1959, **30**, 11.

couplings demonstrates the non-planar conformation of the lactone ring (and therefore of the *O*-isopropylidene ring) as the projected valency angle between $H_{(3)}$ and $H_{(4)}$ has to have a value of *ca.* 90° to explain the observed coupling.

The difference between the optical rotations of these two lactones observed at the Na_D line was rationalised by a study of the shapes of the optical rotatory dispersion curves in acetonitrile and, further, these results confirmed that the lactones had similar conformations. Both compounds exhibited a λ-axis cross-over point at *ca.* 230 mμ and a negative Cotton effect at *ca.* 245 mμ which showed that the carbonyl groups had the same geometric environment [5] in the two compounds. Moreover, the curve of the lactone (I) crossed the λ-axis at *ca.* 280 mμ, so that the optical rotation at the Na_D line was positive, whereas the curve of the isopropylidene derivative (II) did not cross the λ-axis and hence its rotation at the Na_D line was negative. Consequently the difference between the shapes of the optical rotatory dispersion curves is probably due to the change in the electronic character of the 2- and 3-substituents. It is significant that a similar change in optical rotation (+24° ⟶ −31·5°) was observed [1] when the lactone was converted into its 2,3-di-*O*-methyl derivative.

In methanol, the lactone (I) behaved anomalously since the curve had the same general shape as in acetonitrile but exhibited a gradual shift with time towards longer wavelengths, which was not observed with the derivative (II). No rationalisation can be offered for this observation since evidence for a structural change, such as methanolysis, was not obtained from the infrared spectrum (Nujol mull) of recovered material. Further, no reversible equilibrium was detected in solution when the infrared spectrum of the lactone (I) in methanol was examined over a period of several days.

Dr. J. C. P. Schwarz has kindly brought our attention to the fact that on the basis of Hudson's lactone rule [6] a positive Cotton effect for these compounds might be expected, as from the optical rotatory dispersion curves of methylated D-glucono- and D-mannono-1→4-lactones.[7] It is noteworthy that the related D-allono-1→4-lactone is an exception to the rule.

Experimental.—D-Ribono-1→4-lactone (I) and the 2,3-*O*-isopropylidene derivative (II) were prepared by the method of Hough, Jones, and Mitchell.[1]

The proton magnetic resonance spectra were measured at 60 Mc./sec. on a Varian 4300 B spectrometer for *ca.* 0·15M-solutions in acetone and were calibrated with tetramethylsilane as internal reference by the usual sideband technique. Although the spectrum of the 2,3-*O*-isopropylidene derivative (II) could be analysed completely, that of the parent lactone (I) was too complex and the values for this derivative were obtained from an acidified solution. It was necessary to measure this spectrum immediately after the addition of the acid because of the gradual formation of the isopropylidene derivative, the spectrum of which became superimposed on that of the lactone. In the isopropylidene derivative the hydroxyl hydrogen and the isopropylidene methyl groups were apparent at τ 5·53, 8·59, and 8·62, respectively.

The optical rotatory dispersion spectra were measured on a Rudolph model 200 polarimeter.

We thank Mrs. A. H. Wright who measured the optical rotatory disperion spectra and Dr. B. Coxon for his help and advice. One of us (L. D. H.) thanks the D.S.I.R. for a grant and the National Physical Laboratory for a Vacation Studentship (1961).

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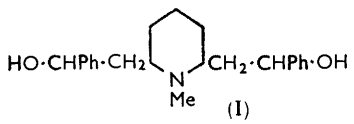
(L. D. H., L. H.) Department of Organic Chemistry, The University, Bristol.
(H. J. M.) National Institutes of Health,
Bethesda, Maryland, U.S.A. [*Received, July 26th,* 1962.]

[5] Djerassi, "Optical Rotatory Dispersion," McGraw-Hill, New York, 1960.
[6] Hudson, *J. Amer. Chem. Soc.*, 1910, **32**, 338; J. W. Green, in "The Carbohydrates," ed. Ward Pigman, Academic Press Inc., New York, 1957, p. 306.
[7] Harris, Hirst, and Wood, *J.*, 1934, 1825; 1935, 295.

133. *A New Alkaloid from* Isotoma longiflora.

By H. R. Arthur and (Miss) Rosalind P. K. Chan.

Isotoma longiflora belongs to the family Lobeliaceae which is the main source of the well-known *Lobelia* alkaloids.[1] We have isolated from this Hong Kong species the two known alkaloids (−)-lobeline and lobelanidine together with a new one in a 0·002% yield from fresh herb. The new alkaloid, $C_{22}H_{29}NO_2$, crystallizes from ether as prisms, m. p. 117°, $[\alpha]_D$ −71·8 ± 1°. The alkaloid contains a methylimino-group, and forms a dibenzoyl derivative indicating the presence of two hydroxyl groups. It does not contain an easily reducible double bond (it was not hydrogenated with Adams catalyst in acetic acid). Mild oxidation with chromic acid in acetic acid solution afforded (−)-lobeline and also lobelanine. Alkaline permanganate oxidation gave benzoic acid. These reactions suggested that the alkaloid is a diphenyl-lobelidiol; its identity with (−)-*cis*-8,10-diphenyl-lobelidiol (I) was confirmed by mixed melting point and comparison of the infrared spectrum with that of a sample kindly supplied by Dr. A. Ebnöther, who obtained it as a minor product (18% yield) from the reduction of (−)-lobeline.[2] (−)-*cis*-8,10-Diphenyl-lobelidiol was characterised as the hydrochloride, m. p. 138—140°, nitrate, and the dibenzoyl derivative, and it formed a crystalline hydrate. It is an optical isomer of lobelanidine and has not been reported previously as naturally occurring.



(I)

It has been reported [3] that an alkaloid, m. p. 125°, forming a hydrochloride, m. p. 160°, occurs in the Peruvian species of *Isotoma longiflora*, but we did not detect such an alkaloid.

Experimental.—Analyses were by Dr. K. W. Zimmermann, Melbourne. M. p.s were taken on a Kofler block. Infrared spectra were measured on Nujol mulls with a Perkin-Elmer Infracord (Model 137) spectrophotometer. The alumina used for chromatography was of B.D.H. analysis grade. Specific rotations were determined in chloroform.

Extraction and isolation. Fresh herb (6 kg.) was extracted with N-hydrochloric acid (18 l.) at room temperature. The extract was filtered, washed twice with ether to remove neutral and acidic substances, and basified with ammonia solution. The liberated bases were taken up in ether, and the ethereal solution washed with water, dried, and distilled. The viscous residue (3·2 g.) was dissolved in benzene (150 ml.) and chromatographed on alumina (100 g.). Elution with benzene (2 l.) gave an oil which on crystallization from ether yielded needles of (−)-lobeline (40 mg.), m. p. and mixed m. p. 130°, $[\alpha]_D^{20}$ −39·7° ±2° (*c* 1·92) (Found: C, 77·7; H, 8·0; N, 4·1. Calc. for $C_{22}H_{27}NO_2$: C, 78·3; H, 8·1; N, 4·15%). The infrared spectrum was found to be identical with that of (−)-lobeline.

Further elution with 5% ether in benzene (2 l.) and evaporation of the solvent yielded a yellowish syrup which solidified after two days and gave crystals on trituration with a little ether. Recrystallization from ether yielded (−)-cis-8,10-*diphenyl-lobelidiol* as prismatic crystals (120 mg.), m. p. 117°, $[\alpha]_D^{20}$ −71·8° ± 1° (*c* 1·16) [Found: C, 77·85; H, 8·5; N, 4·5; NMe, 4·0%; *M* (Rast), 295. $C_{22}H_{29}NO_2$ requires C, 77·8; H, 8·6; N, 4·1; NMe, 4·4%; *M*, 339]. On repeated treatment with moist ether, *a hydrate* was obtained which was sparingly soluble in ether and gave needles (from acetone), m. p. 216—218° (decomp.) (Found: C, 73·8; H, 8·2; N, 4·0. $C_{22}H_{29}NO_2,H_2O$ requires C, 73·9; H, 8·7; N, 3·9%).

The column was eluted further with 50% ether in benzene (1·5 l.), and the combined fractions were evaporated to dryness. Crystallization of the residue from ethanol gave prisms (25 mg.), m. p. 150°, $[\alpha]_D^{20}$ 0° (*c* 1·20) (Found: C, 77·8; H, 8·8; N, 4·20. Calc. for $C_{22}H_{29}NO_2$: C, 77·8; H, 8·6; N, 4·1%). The infrared spectrum was identical with that of lobelanidine, and the m. p. was not depressed in admixture with an authentic sample.

Derivatives of (−)-cis-8,10-*diphenyl-lobelidiol.* The *nitrate* was prepared by dissolving the base (20 mg.) in nitric acid (1 : 1), and the mixture left for several days. The product deposited was recrystallized from methanol and gave needles, m. p. 216—217° (Found: C, 65·4; H, 7·5. $C_{22}H_{30}N_2O_5$ requires C, 65·65; H, 7·5%).

[1] Manske and Holmes, "The Alkaloids," Academic Press Inc., New York, Vol. I, 1950, p. 189.
[2] A. Ebnöther, *Helv. Chim. Acta*, 1958, **41**, 386.
[3] Sanchez, *Rev. Med. exptl.* (*Peru*), 1945, **4**, 284; *Chem. Abs.*, 1948, **42**, 1350.

The base was benzoylated by the Schotten–Baumann method. On working up by the usual procedure and crystallizing the product from methanol, the *dibenzoyl derivative* was obtained as prisms, m. p. 141—142° (Found: C, 78·6; H, 6·9; N, 2·5. $C_{36}H_{37}NO_4$ requires C, 78·95; H, 6·8; N, 2·6%).

Oxidation with chromic acid in acetic acid. The alkaloid (100 mg.) was dissolved in the minimum amount of acetic acid, and a solution of chromic acid (containing 0·5 g. of chromium trioxide in 2 ml. of water) was added dropwise with stirring. The mixture was left at room temperature for 1 hr. and the product extracted with ether after basification. The residue, on removal of the solvent, was dissolved in benzene–light petroleum (1 : 1) and chromatographed over alumina (5 g.). Ten fractions were collected (200 ml.). Fractions 3—6 gave a glass which on crystallization from ether afforded needles, m. p. 130°, which proved to be identical with authentic (−)-lobeline (mixed m. p. and infrared spectra). The non-crystallized fractions were combined, dissolved in acetic acid, and subjected to further oxidation at 40—50° for 20 min. The product was extracted with ether after basification and was isolated as its hydrochloride by passing dry hydrogen chloride into its solution in dry ether. Recrystallization from alcohol–ether gave needles, m. p. 188°, which were identical in m. p., mixed m. p., and infrared spectrum with the hydrochloride prepared from authentic lobelanine.

Oxidation with alkaline potassium permanganate. The alkaloid (100 mg.) was suspended in 5 ml. of 8% sodium hydroxide, and a solution of potassium permanganate (5%) added dropwise with stirring at about 60° until persistence of a purplish colour. The mixture was decolorized with sulphur dioxide and extracted with ether. The residue obtained on evaporation of the solvent was sublimed under vacuum. The sublimate was benzoic acid (m. p., mixed m. p., and infrared spectrum). The non-sublimed fraction was a brownish mass which could not be characterized.

The authors thank Professor J. Miller for his interest, Mr. H. C. Tang (Government Herbarium, Hong Kong) for identification of plant material, Dr. A. Ebnöther (Sandoz, Basel, Switz.) and Professor E. Steinegger (University of Berne, Switz.) for samples, the Tropical Products Institute, D.S.I.R. (London), and the Research Grants Committee of the University of Hong Kong for grants-in-aid.

UNIVERSITY OF HONG KONG, HONG KONG. [*Received, August 2nd,* 1962.]

134. *Steric Effects in the Solvolysis of Aralkyl Chlorides.*

By A. FISCHER, D. I. STEDMAN, and J. VAUGHAN.

BADDELEY *et al.*[1] found that for solvolysis of aralkyl chlorides CHPhRCl the rate sequence is R = Me > Et > Pr^i > Bu^t. They suggested that the rate order is determined by increasing steric inhibition of resonance in the substituted benzyl cation. Later studies [2] by Baddeley, Rasburn, and Rose on chloroindane and chlorotetralin derivatives produced evidence for other factors leading to such rate trends. Two such factors discussed by Baddeley *et al.* are steric inhibition of solvation of the cation and loss of hyperconjugative stabilisation of the ion.

Any evidence implying that steric inhibition of resonance is negligible in the ion Bu^tPhCH^+ would clearly indicate that this factor is unimportant in establishing the trend of the solvolysis rates found for the aralkyl chloride series. Such evidence appears to be provided indirectly by solvolysis results for such chlorides given in Table 1 (values in parentheses are based on rate constants found at lower temperatures).

Using rate and σ° data [3] for the *meta*-substituted phenyl groups and for phenyl leads to a Hammett reaction constant (ρ) of −4·79. The correlation coefficient r is 0·997, and the intercept of the regression line with the ordinate, log k_0, is −4·00. If resonance in the incipient cation transition state is free from steric inhibition, then *para* $+M$-substituents will require effective substituent constants ($\bar{\sigma}$) exalted in the direction of σ^+ values; [4]

[1] Baddeley, Chadwick, and Taylor, *J.*, 1954, 2905.
[2] Baddeley, Rasburn, and Rose, *J.*, 1958, 3168.
[3] Taft, *J. Phys. Chem.*, 1960, **64**, 1805.
[4] Okamoto and Brown, *J. Org. Chem.*, 1957, **22**, 485.

substantial restriction will result in unenhanced values and in Taft–Wepster resonance terms $2{\cdot}3\boldsymbol{R}T\psi(\text{Taft}) = -\Delta\Delta F_p(\text{Wepster})$ [5] $= 2{\cdot}3\boldsymbol{R}T\rho(\bar{\sigma} - \sigma^\circ)$ approaching zero.

The figures listed in Table 2 indicate that resonance interaction in the incipient α-t-butylbenzyl cation is similar in magnitude to that in the $ArMe_2C^+$ ion.

TABLE 1.

Solvolysis of $Bu^tArCHCl$ in 3 : 7 w/w aqueous ethanol.

Ar	10^5k (sec.$^{-1}$) at 94·7°	65·0°	34·9°	Ar	10^5k (sec.$^{-1}$) at 94·7°	65·0°	34·9°
C_6H_5	10·3			p-C_6H_4Cl	4·09		
m-C_6H_4Br	0·172			m-C_6H_4Me	20·8		
p-C_6H_4Br	2·86			p-C_6H_4Me	(131)	6·52	0·167
p-$C_6H_4Bu^t$	(290)	13·7	0·334	p-C_6H_4·OMe	(66,100) *		
m-C_6H_4Cl	0·122						

* From $10^5k = 47{\cdot}4$ at 3·75° and 2·19 at −22·8°.

TABLE 2.

$\bar{\sigma}$ values and resonance terms for solvolysis of $CHBu^tArCl$ and of CMe_2ArCl.[4]

Ar	p-C_6H_4Br	p-$C_6H_4Bu^t$	p-C_6H_4Cl	p-C_6H_4Me	p-C_6H_4·OMe
$\bar{\sigma}$	0·11	−0·31	0·08	−0·23	−0·80
$2{\cdot}3\boldsymbol{R}T\psi$	1·2	0·9	1·2	0·8	5·5
σ^+	0·15	−0·25	0·11	−0·31	−0·76
$2{\cdot}3\boldsymbol{R}T\psi^+$	0·7	0·4	0·8	1·2	4·2

Experimental.—Alcohols. α-t-Butylbenzyl alcohol was prepared as follows: redistilled benzaldehyde (40 g.) in dry ether (100 ml.) was added during 2·5 hr., with stirring, to the Grignard reagent from magnesium (23 g.) and t-butyl chloride (102 g.) in ether (300 ml.) cooled in ice–salt. Next morning the mixture was poured on a stirred mixture of saturated ammonium chloride solution (400 ml.) and ice (200 g.). The aqueous layer was separated and extracted with ether, and the combined ethereal solutions were washed with water, 5% aqueous sodium hydrogen carbonate, and water and dried ($MgSO_4$). After removal of the ether, the residue was distilled under a vacuum and the alcohol was collected at 100—105°/9 mm. It solidified and was recrystallised twice from light petroleum (b. p. 40—60°), then having m. p. 44·5° (yield, 38%).

The following analogues were similarly prepared: 4-chloro- (30%), b. p. 121°/5 mm., 4-bromo- (40%), b. p. 135°/5 mm., 4-methoxy- (70%), b. p. 132°/5 mm., m. p. 41—42°, *3-chloro-* (51%). b. p. 118°/5 mm., n_D^{25} 1·5200 (Found: C, 66·3; H, 7·5; Cl, 17·7. $C_{11}H_{15}ClO$ requires C, 66·5; H, 7·6; Cl, 17·8%), *3-bromo-* (46%), b. p. 132°/5 mm., n_D^{25} 1·5420 (Found: C, 54·0; H, 6·2; Br, 33·2. $C_{11}H_{15}BrO$ requires C, 54·3; H, 6·2; Br, 32·9%), *3-methyl-* (50%), b. p. 107°/5 mm., n_D^{25} 1·5072 (Found: C, 81·4; H, 10·3. $C_{12}H_{18}O$ requires C, 80·9; H, 10·2%), and *4-methyl-α-t-butylbenzyl alcohol* (36%), b. p. 101°/5 mm., n_D^{25} 1·5120 (Found: C, 80·9; H, 9·8%). $C_{12}H_{18}O$ requires C, 80·9; H, 10·2%). α,*4-Di-t-butylbenzyl alcohol*, m. p. 81°, was obtained by reduction [5] of *p*-t-butylpivalophenone with lithium aluminium hydride (Found: C, 81·8; H, 10·6. $C_{15}H_{24}O$ requires C, 81·8; H, 11·0%).

Chlorides. The appropriate alcohol (1 mol.) was added to freshly distilled thionyl chloride (2·5 mol.). After 15 hr. the excess of thionyl chloride was removed under a vacuum and the residual chloride taken up in ether, washed with ice–water and cold sodium hydrogen carbonate solution, and dried ($MgSO_4$). The ether was removed and the chloride was fractionated under a vacuum. Aqueous washing was avoided for the more reactive 4-methoxy- and 4-methyl-α-t-butylbenzyl chlorides. Physical properties, etc., of the chlorides are listed in Table 3. Of the listed compounds, only those in which X = H and *p*-Cl have been reported elsewhere.

Solvent. Absolute ethanol was distilled successively from 12N-sulphuric acid (2·5%) and from solid sodium hydroxide, and then fractionated. The middle fraction was diluted to 70·0% (by weight), this value being confirmed by density measurement.

Preliminary measurements indicated that most rates could be measured in 70% ethanol at 90°. The more rapidly reacting 4-t-butyl, 4-methoxy-, and 4-methyl-α-t-butyl benzyl chlorides were studied at two lower temperatures and rates at 95° were determined by extrapolation.

Kinetics. The reaction mixture of 25 ml. of 0·03M-chloride in aqueous ethanol was

[5] Brewster, Patterson, and Fidler, *J. Amer. Chem. Soc.*, 1954, **76**, 6368,

TABLE 3.

Physical properties and analysis of X·C_6H_4·CHBu^{t}Cl.

X	B. p./mm.	n_D (temp.)	Halogen (%) Found	Reqd.
H	90°/6	1·5144(25°)	—	—
3-Br	117°/2	1·5498(23°)	43·9	44·1
4-Br	122°/2	1·5434(21·5°)	*	—
3-Cl	108°/3	1·5309(21·5°)	32·3	32·7
4-Cl	118°/4	1·5305(21·5°)	32·4	32·7
4-OMe	113°/2	1·5260(20°)	16·3	16·7
3-Me	99°/2	1·5150(21°)	18·1	18·0
4-Me	104°/5	1·5164(20°)	17·9	18·0
4-Bu^t	105°/4 (m. p. 57—58°)		14·7	14·9

* Analytical figures for halogen varied unaccountably over a range within 2% of the required value. There was no evidence, however, either from b. p. or kinetic runs, that the compound was impure.

prepared at room temperature. Nine aliquot parts (2·5 ml.) were pipetted into ampoules which were then sealed and placed in the thermostat-bath. At selected times an ampoule was withdrawn and cooled. The contents were diluted with ethanol and the liberated acid was titrated with aqueous barium hydroxide. For the more reactive 4-methoxy-α-t-butyylbenzyl chloride aliquot parts (2·5 ml.) (from 25 ml. of solution) were added to ice-cold absolute alcohol and titrated with barium hydroxide. A carbon tetrachloride cryostat was used for runs at −23°. The k values given in Table 1 are the mean of three runs and are estimated to be accurate to ±5%.

We thank Dr. A. D. Campbell, University of Otago, for the microanalyses.

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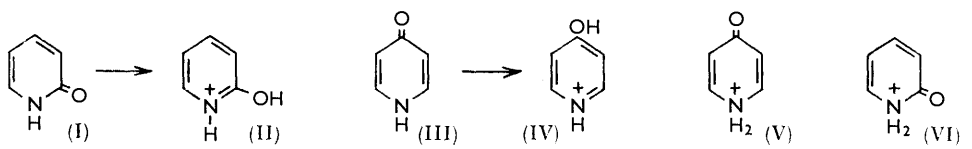
135. *Applications of Proton Resonance Spectroscopy to Structural Problems. Part VIII.*[1] *2-Pyridone Cations.*

By A. R. KATRITZKY and R. E. REAVILL.

THE *O*-protonation of pyridones (I ⟶ II, III ⟶ IV) has for long been a fundamental tenet of heterocyclic chemistry.[2] Spinner [3] challenged the ultraviolet data that were the previous evidence for *O*-protonation, and advanced infrared and Raman spectral evidence for *N*-protonation (I ⟶ VI, III ⟶ V). However, the evidence from vibra-



tional spectra is not convincing: the bands at *c. a.* 1640 cm.$^{-1}$, postulated as being ν(CO), could well be ring-stretching modes. Moreover, it has become apparent that amides are *O*-protonated by acids quite generally.[4] Therefore, investigation has been made in this Laboratory of the proton resonance spectra of some 2- and 4-pyridones. The results provide conclusive evidence for predominant *O*-protonation: they have been published for the 4-series [5] and are presented here for the 2-series.

Chemical shifts (p.p.m., τ scale), multiplicities, and coupling constants (c./sec.) are shown for the three 2-pyridones which were measured in sulphuric acid (VII—IX) and

[1] The following papers by Katritzky and others are considered as Parts I—VII, respectively, of this series: *Proc. Chem. Soc.*, 1960, 313; *Chem. and Ind.*, 1960, 870; 1961, 990, 1530; 1962, 695; *Monatsh.*, 1962, **93**, 542; *Annalen*, 1962, in the press.

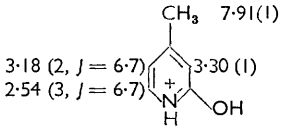
[2] Cf. Katritzky and Lagowski, "Heterocyclic Chemistry," Methuen, London, 1960, pp. 51—52, 90.

[3] Spinner, *J.*, 1960, 1226; cf. Sensi and Gallo, *Ann. Chim.* (*Italy*), 1954, **44**, 232.

[4] Katritzky and Jones, *Chem. and Ind.*, 1961, 722.

[5] Katritzky and Jones, *Proc. Chem. Soc.*, 1960, 313.

deuterosulphuric acid (X—XII). For 4-methyl-2-pyridone (VII) in sulphuric acid, the 6-proton peak appears as a triplet, indicating approximately equal coupling with the 5-proton and *one* proton on the nitrogen atom. For 5-methyl- (VIII) and 5-chloro-2-pyridone (IX), the 6-proton appears as a quadruplet, and the coupling constants indicate one *ortho*-proton. In the last two compounds, *meta*-coupling between the NH and the 3-proton can also be distinguished. These assignments are confirmed by the spectra obtained in deuterosulphuric acid (X—XII).



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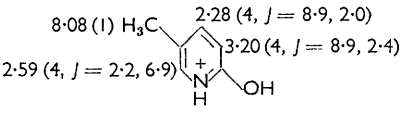

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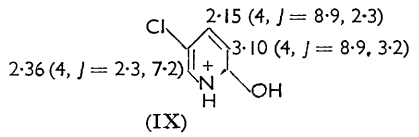

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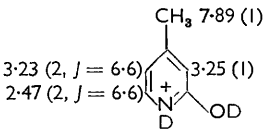

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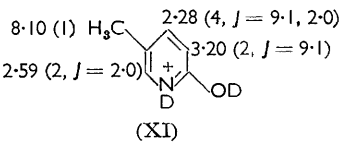
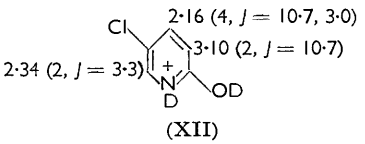


(XI)



(XII)

Dr. Ludwig Bauer and Dr. Charles Bell of the College of Pharmacy, University of Illinois (whom we thank for an interesting discussion) have informed us that they have obtained independent infrared evidence for the *O*-protonation of 2-pyridones.[6]

Experimental.—The 2-pyridones were prepared for the corresponding 2-aminopyridines by diazotisation,[7] namely: 4-methyl-, m. p. 129—129·5° (lit.,[8] m. p. 130°), 5-methyl-, m. p. 186·5—187·5° (lit.,[9] m. p. 182—183°), and 5-chloro-2-pyridone, m. p. 162·5° (lit.,[7] m. p. 163°). Hexachloroantimonates were prepared in concentrated hydrochloric acid from equimolar quantities of the base and antimony pentachloride and recrystallised for the same solvent: *4-methyl-*, needles, m. p. 120—122° (Found: C, 16·0; H, 2·2; N, 3·4. $C_6H_8Cl_6NOSb$ requires C, 16·2; H, 1·9; N, 3·2%), *5-methyl-*, needles, m. p. 198—199° (Found: C, 16·5; H, 2·1; N, 3·0), and *5-chloro-2-pyridone hexachloroantimonate*, needles, m. p. 228—229° (Found: C, 12·7; H, 1·4; N, 3·0. $C_5H_5Cl_7NOSb$ requires C, 12·9; H, 1·1; N, 3·0%).

Spectra were obtained at 40 Mc./sec. on a Perkin-Elmer nuclear magnetic resonance spectrometer with sample spinning. Tetramethylsilane was used as an internal reference. Concentrations were approximately 10% w/v.

This work was carried out during the tenure (by R. E. R.) of a D.S.I.R. Studentship.

THE UNIVERSITY CHEMICAL LABORATORY, CAMBRIDGE. [*Received, July 16th,* 1962.]

[6] Bell, Shoffner, and Bauer, personal communication.
[7] Tschitschibabin and Jegrow, *J. Russ. Phys. Chem. Soc.*, 1928, **60**, 683; *Chem. Zentr.*, 1928, II, 1671.
[8] Seide, *Ber.*, 1924, **57**, 793.
[9] Case, *J. Amer. Chem. Soc.*, 1946, **68**, 2576.

136. *A Stable Chlorodithio-compound from Benz*[a]*anthracene.*

By Z. S. Ariyan and L. A. Wiles.

We recently studied the chlorodithio-derivatives of polycyclic aromatic hydrocarbons.[1] These have only been isolated when the hydrocarbon has one or more carbon atoms with a free valency value [2] $> \sim 0.5$. The few compounds known are rapidly hydrolysed in moist air.

We now report that 7-chlorodithiobenz[*a*]anthracene is unchanged by exposure to the air for 24 hours. This compound was previously obtained, as an impure intermediate and without characterisation, by Wood and Fieser [3] during a study of carcinogenic compounds.

Increase in the maximum free valency of a carbon atom may either decrease or increase the reactivity of an attached side-chain.[4] The maximum free valency of benz[*a*]-anthracene (0·514, 7-position) is less than that of anthracene (0·520, 9- and 10-positions) but the chlorodithio-compound of the latter is the more readily hydrolysed. This increase in the reactivity of a substituent with increase in the free valency has a parallel in the S_N2 type solvolysis of chloromethyl derivatives of aromatic hydrocarbons, *e.g.*, 9-chloromethylanthracene is solvolysed 65 times faster than 7-chloromethylbenz[*a*]anthracene.[5]

7-Chlorodithiobenz[*a*]anthracene has the characteristic reactions of chlorodithio-compounds. When refluxed in benzene it loses chlorine to give a tetrasulphide, and its reactive halogen atom condenses with thiophenol, giving a trisulphide.

Experimental.—7-Chlorodithiobenz[*a*]anthracene was prepared by Wood and Fieser's method.[3] It recrystallised from light petroleum (b. p. 60—80°)–benzene as yellowish-red plates, m. p. 120° (52%) (Found: C, 66·1; H, 3·4; Cl, 10·5; S, 19·3. $C_{18}H_{11}ClS_2$ requires C, 66·1; H, 3·4; Cl, 10·9; S, 19·6%).

Di-(*7-benz*[a]*anthryl*) *tetrasulphide.* 7-Chlorodithiobenz[*a*]anthracene, when refluxed for 20 hr. in benzene solution, gave the *tetrasulphide*, which recrystallised from light petroleum as yellow needles, m. p. 193—194° (decomp.) (25%) (Found: C, 73·7; H, 4·0; S, 21·1. $C_{36}H_{22}S_4$ requires C, 74·2; H, 3·8; S, 22·0%).

7-(*Benz*[a]*anthryl*) *phenyl trisulphide.* 7-Chlorodithiobenz[*a*]anthracene, when refluxed for 3 hr. with thiophenol in benzene, gave this *trisulphide*, which recrystallised from benzene as yellow needles, m. p. 125° (60%) (Found: C, 72·1; H, 4·3; S, 23·5. $C_{24}H_{16}S_3$ requires C, 71·9; H, 4·0; S, 24·0%).

Department of Chemistry and Metallurgy, Royal Military College of Science, Shrivenham, Swindon, Wilts. [*Received, August 14th*, 1962.]

[1] Ariyan and Wiles, *J.*, 1962, 1725.
[2] Pullman and Pullman, in "Progress in Organic Chemistry," ed. Cook, Butterworths Scientific Publns., London, 1958, Vol. IV, p. 31.
[3] Wood and Fieser, *J. Amer. Chem. Soc.*, 1940, **62**, 2674.
[4] Ref. 2, p. 62.
[5] Fierens, Hannaert, Van Rysselberge, and Martin, *Helv. Chim. Acta*, 1955, **38**, 2009.

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137. *Reaction of Steroidal Alcohols with Isobutene: Usefulness of t-Butyl as Hydroxyl-protecting Group in a Synthesis of Testosterone.*

By H. C. Beyerman and G. J. Heiszwolf.

The t-butoxy-group, in this case alkali-resistant but acid-labile, was introduced as a novel hydroxyl-protecting group for use in peptide synthesis with hydroxy-amino-acids.[1,2] The method was then used for protecting the thiol group in the synthesis of peptides containing cysteine after suitable modification.[3]

We have now found that, in the cases investigated by us, acid-catalysed addition of

[1] Beyerman and Bontekoe, *Proc. Chem. Soc.*, 1961, 249.
[2] Beyerman and Bontekoe, *Rec. Trav. chim.* 1962, **81**, 691.
[3] Beyerman, Kuivenhoven-Noordam, and Lafeber, ref. 2, footnote 9.

isobutene to steroidal alcohols gives high yields of t-butyl ethers. t-Butyl ethers of steroid alcohols have not previously been prepared and have not been found to occur naturally. The experimental procedure was as described,[2] except that the amount of acid had to be increased. In several cases a boron trifluoride–phosphoric acid catalyst was found to be superior to sulphuric, hydrochloric, or toluene-*p*-sulphonic acid. A few details of a range of t-butyl ethers so prepared are listed in the Table. It is to be noted that reaction gave high yields with hydroxyl groups on five- and six-membered rings, in equatorial and in axial position, and with phenolic compounds.

Reaction of some steroidal alcohols with isobutene.

	t-Butyl ether *	
Alcohol	M. p.	$[\alpha]_D$ in $CHCl_3$
Cholestanol, 5α-cholestan-3β-ol	142—143°	+19°, $c = 1$
Cholesterol, cholest-5-en-3β-ol	172—173	−35 , $c = 4$
Dehydroepiandrosterone, 3β-hydroxyandrost-5-en-17-one	174—179	+1 , $c = 1$
Androsterone, 3α-hydroxy-5α-androstan-17-one	139—140	+78 , $c = 1$
Testosterone, 17β-hydroxyandrost-4-en-3-one	165—166	+103 , $c = 2{\cdot}4$
3β-Hydroxyandrost-5-en-17β-yl benzoate	205—208	+4 , $c = 1$
Œstrone, 3-hydroxyœstra-1,3,5(10)-trien-17-one	161—162	+137 , $c = 1$
Œstradiol, 3-hydroxyœstra-1,3,5(10)-trien-17β-ol	125	+60 , $c = 1$

* Each compound gave a satisfactory carbon–hydrogen analysis and, according to these analyses and infrared spectra, all the hydroxyl groups had reacted.

The t-butoxy-group was removed easily, by splitting the t-butyl–oxygen bond with trifluoroacetic acid, in a way similar to our published procedure.[1,2]

The usefulness of our method in steroid chemistry is demonstrated by a simple synthesis of testosterone. Dehydroepiandrosterone, which may be obtained from cholesterol or diosgenin, was converted into the t-butyl ether (see Table; yield ~90%). Reduction of this compound with lithium aluminium hydride in ether yielded 3β-t-butoxyandrost-5-en-17β-ol (m. p. 178—179°, $[\alpha]_D$ −52°, $c = 1$ in $CHCl_3$) (~95%). Treatment with benzoyl chloride in pyridine gave 3β-t-butoxyandrost-5-en-17β-yl benzoate (m. p. 207—210°; ~80%), which was identical with the compound obtained by reaction of isobutene with 3β-hydroxyandrost-5-en-17β-yl benzoate (see Table). The t-butyl group was split off in the usual way, and we obtained the known 3β-hydroxyandrost-5-en-17β-yl benzoate (m. p. 218—220°; ~90%). Oppenauer oxidation of the latter compound to testosterone benzoate has been described.[4]

We thank N.V. Organon, Oss, for gifts of materials.

Laboratory of Organic Chemistry, Technische Hogeschool,
Delft, Holland. [*Received, August 17th*, 1962.]

[4] Ott, Murray, and Pederson, *J. Amer. Chem. Soc.*, 1952, **74**, 1239.

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138. *Mixed Substitution Compounds of Hexacarbonylmolybdenum.*

By M. H. B. Stiddard.

In previous work,[1] it was apparently impossible to replace more than two carbonyl groups attached to a Group VI metal by the bidentate ligand 2,2′-bipyridyl. This behaviour contrasts with that of the diphosphine $(CH_2{\cdot}PR_2)_2$ [2] and the diarsine o-$C_6H_4(AsMe_2)_2$ [3] which are capable of replacing four carbonyl groups, and results probably from the poorer π-acceptor properties of the bipyridyl than of these other ligands. The degree of metal–bipyridyl π-bonding in the compounds $M(CO)_4$(bipy) must affect particularly the strength

[1] Stiddard, *J.*, 1962, 4712.
[2] Chatt and Watson, *J.*, 1961, 4980.
[3] Nigam, Nyholm, and Stiddard, *J.*, 1960, 1803.

of the metal–carbon bonds in the *trans*-positions where carbonyls groups are more strongly bound than in the *cis*-positions. Indeed, one would here expect particular difficulty in replacing the strongly bound *trans*-carbonyl groups and hence the improbability of obtaining the bisbipyridyl compounds. The present investigation shows, on the other hand, that in tetracarbonylbipyridylmolybdenum a carbonyl group *cis* to the bipyridyl is replaced readily by several ligands, to give complexes of the type $Mo(CO)_3(bipy)L$, where L = Ph_3P, Ph_2S, or C_5H_5N. Physical measurements, shown in Table 1, indicate that the

TABLE 1.

Physical properties of complexes.

No.	Compound	Colour	Mol. conductance (ohm^{-1} $cm.^2$) of 10^{-3}M-solutions in nitrobenzene *	C–O stretching frequencies † ($cm.^{-1}$) in 1,2-dichloroethane
1	$Mo(CO)_3(bipy)Ph_3P$	Purple	0·56	1913, 1820, 1792
2	$Mo(CO)_3(bipy)Ph_2S$	Brown	1·32	1903, 1883, 1840
3	$Mo(CO)_3(bipy)C_5H_5N$	Deep red	1·16	1905, 1880, 1832

* Solutions rather unstable. † All bands are very strong.

products are diamagnetic and non-electrolytes. Solubilities are rather low and preclude molecular-weight measurements. Infrared spectra show the expected three maxima in the C–O stretching region; in this region the spectra are very similar in profile to those of the complexes $Mn(CO)_3$(bidentate)Hal,[4] but naturally the maxima occur at lower frequencies. Complexes of the latter type have the *cis*-configuration.[5]

The ease of removal of a *cis*-carbonyl group from tetracarbonylbipyridylmolybdenum by the monodentate ligands mentioned above supports the suggestion that the increasing difficulty found in replacing consecutive pairs of carbonyl groups by bidentate ligands (particularly those with poor π-acceptor properties) results mostly from the increased metal–carbon bond order in the positions *trans* to the ligand.

Experimental.—Preparation of complexes. Tetracarbonylbipyridylmolybdenum (*ca.* 0·5 g.) was heated under nitrogen with the ligand for ~30 min. at the temperatures indicated in Table 2. After cooling, the product was washed free from ligand with light petroleum (3 × 10 ml.) and dried *in vacuo*. The *compounds* prepared, and the yields and analyses, are

TABLE 2.

Preparation and analysis of complexes.

			Found (%)						Required (%)				
No.	Reaction temp.	Yield (%)	C	H	N	S	Mo	Formula	C	H	N	S	Mo
1	160°	91	62·2	3·5	4·4	—	*	$C_{31}H_{23}MoN_2O_3P$	62·3	3·8	4·7	—	—
2	160	62	56·9	3·6	5·7	6·4	18·0	$C_{25}H_{18}MoN_2O_3S$	57·5	3·4	5·4	6·1	18·4
3	120	89	52·3	3·6	10·3	—	22·7	$C_{18}H_{13}MoN_3O_3$	52·1	3·2	10·1	—	23·1

* Phosphorus interferes with metal analysis.

given in Table 2. The compounds are stable in air, only slightly soluble in polar and non-polar solvents, and insoluble in petroleum. They are diamagnetic in the solid state at 20°.

Molybdenum was determined as described previously.[1]

This work was carried out in the University of Hull, whose hospitality is gratefully acknowledged.

WILLIAM RAMSAY AND RALPH FORSTER LABORATORIES,
UNIVERSITY COLLEGE, GOWER STREET, LONDON, W.C.1. [*Received, August 20th*, 1962.]

[4] Osborne and Stiddard, *J.*, 1962, 4715.
[5] Abel and Wilkinson, *J.*, 1959, 1501.

139. 3-(2,3-*Dihydroxypropyl*)*salicylic Acid and Related Compounds.*

By C. J. W. Brooks and W. L. Stafford.

Observations on the therapeutic use of *o*-cresotic acid [1] prompted the preparation of 3-(dihydroxyalkyl)salicylic acids (3-substituted 2-hydroxybenzoic acids), with the aim of securing improved solubility in water.

Permanganate oxidation of 3-allylsalicylic acid gave 3-(2,3-dihydroxypropyl)salicylic acid. The corresponding methyl ester was oxidised by periodate to methyl 3-formylmethylsalicylate, characterised as its 2,4-dinitrophenylhydrazone, which showed ultraviolet absorption typical of a saturated 2,4-dinitrophenylhydrazone. An attempt to oxidise this aldehyde to the corresponding acid yielded as the only crystalline product a substance which appeared to be a hydrate of the aldehyde from its analysis, the absence of aldehyde absorption bands in the infrared, and its conversion into the same 2,4-dinitrophenylhydrazone. Preparation of this substance by direct acid-catalysed hydration was, however, not achieved.

3-2′-Methylallylsalicylic acid was prepared by Claisen rearrangement of methyl *O*-2′-methylallylsalicylate, followed by hydrolysis. Permanganate oxidation of the methyl ester gave the methyl ester of 3-(2,3-dihydroxy-2-methylpropyl)salicylic acid, which was oxidised by lead tetra-acetate to methyl 3-acetonylsalicylate. The infrared absorption of this ester showed three concentration-independent bands in the carbonyl region, at 1680, 1716, and 1729 cm.$^{-1}$. The 1680 cm.$^{-1}$ band is typical of salicylates,[2] and the last two bands possibly arise from two conformations of the acetonyl group. Infrared absorption of other compounds described was in accordance with the proposed structures.

Approximate solubilities of these salicylic acids in water (in g./100 ml.) at 100° and 18° were: 3-(2,3-dihydroxypropyl) 17, 0·5; 3-(2,3-dihydroxy-2-methylpropyl) 5, 0·5; *o*-cresotic acid, 1, 0·05.

Experimental.—3-Allylsalicylic acid,[3] prepared by the Claisen rearrangement, had m. p. 95°, $\lambda_{max.}$ (in EtOH) 208, 240, 308 mμ (log ε 4·56, 3·86, 3·67).

3-(2,3-*Dihydroxypropyl*)*salicylic acid.* (i) A solution of potassium permanganate (474 mg., 3 mmoles) in water (60 ml.) was added during 10 min. to a stirred solution, kept at 3°, of 3-allylsalicylic acid (270 mg., 1·5 mmoles) in 0·02N-aqueous sodium hydroxide (250 ml.). The mixture was decolorised by sulphur dioxide, diluted with brine, and extracted with ether, affording a product (161 mg.) which on recrystallisation from ether–ethyl acetate and then from water gave the *acid* as prisms (76 mg., 23%), m. p. 150—151° (Found: C, 56·55; H, 5·7. $C_{10}H_{12}O_5$ requires C, 56·6; H, 5·7%). The *methyl ester*, prepared with diazomethane, had m. p. 77—78° (needles, from ether–light petroleum), $\nu_{max.}$ (in Nujol) 1670, 3280 cm.$^{-1}$ (Found: C, 58·9; H, 6·45. $C_{11}H_{14}O_5$ requires C, 58·4; H, 6·25%). (ii) A solution of methyl 3-allylsalicylate (980 mg., 5 mmoles) in acetone (200 ml.) and water (250 ml.) was cooled to −10°, stirred, and treated with 0·1N-aqueous sodium hydroxide (100 ml.). The turbid solution was kept at 2—6° while an aqueous solution (250 ml.) of potassium permanganate (1·58 g., 10 mmoles) was added during 20 min. Working up as in (i) afforded the methyl ester (600 mg., 52%), m. p. 74—77°, hydrolysis of which by 1·6N-sodium hydroxide at room temperature gave the acid (500 mg., 43%), m. p. 150—151°.

Methyl 3-*formylmethylsalicylate.* A cooled solution (0°) of methyl 3-(2,3-dihydroxypropyl)-salicylate (142 mg.) in ethanol (10 ml.) was mixed with 0·15N-aqueous periodic acid (10 ml.) containing sodium acetate (150 mg.), kept at room temperature for 20 min. (0·90 mol. of oxidant consumed), then poured into aqueous sodium hydrogen carbonate. Extraction afforded an oily product. Repeated low-temperature recrystallisations from ether–light petroleum gave the *aldehyde*, m. p. 35—37°, $\nu_{max.}$ (in CCl_4) 1680, 1727, 2710, 2810 cm.$^{-1}$ (Found: C, 62·0; H, 5·65. $C_{10}H_{10}O_4$ requires C, 61·85; H, 5·2%). The 2,4-*dinitrophenylhydrazone* formed orange-yellow needles (from ethyl acetate), m. p. 205—206°, $\lambda_{max.}$ (in $CHCl_3$) 358 mμ (log ε 4·41) (Found: C, 51·6; H, 4·2; N, 15·05. $C_{16}H_{14}N_4O_7$ requires C, 51·35; H, 3·75; N, 14·95%).

[1] Lightbody and Reid, *Brit. Med. J.*, 1960, I, 1704.
[2] Brooks, Eglinton, and Morman, *J.*, 1961, 661.
[3] Claisen, *Ber.*, 1912, **45**, 3157.

The crude aldehyde (100 mg.) was dissolved in acetic acid (5 ml.), mixed with 30% hydrogen peroxide (1 ml.), and kept for 2 days at room temperature. Working-up gave gummy neutral (75 mg.) and acidic (20 mg.) fractions. The former, stirred with light petroleum, gave a *substance* (24 mg.), recrystallising from ether as needles, m. p. 111—112°, $\nu_{max.}$ (in Nujol) 1670 cm.$^{-1}$, no aldehyde absorption in C=O or C–H region (Found: C, 57·2; H, 5·55. $C_{10}H_{12}O_5$ requires C, 56·6; H, 5·7%). The 2,4-dinitrophenylhydrazone, m. p. 205—207°, did not depress the m. p. of the derivative prepared directly from the aldehyde. The same derivative was obtained from the crude product isolated after treatment of the substance, m. p. 111—112°, with periodic acid.

2′-Methylallylsalicylic acid. Methyl *O*-2′-methylallylsalicylate was prepared (without isolation) from 2-methylallyl chloride and methyl salicylate by the general procedure of Nummy and Tarbell.[4] The crude ester (4 g.) was refluxed in dimethylaniline (8 ml.) under nitrogen for 2 hr. Extraction and distillation gave crude methyl 3-2′-methylallylsalicylate (2·9 g.) which was refluxed with Claisen's alkali for 30 min., to yield the *acid* which sublimed at 140°/0·2 mm. and had m. p. 119—121° (Found: C, 68·75; H, 6·15. $C_{11}H_{12}O_3$ requires C, 68·75; H, 6·25%).

3-(2,3-Dihydroxy-2-methylpropyl)salicylic acid. This *acid*, prepared by permanganate oxidation of methyl 3-2′-methylallylsalicylate followed by hydrolysis [according to method (ii) described above for the 3-allyl ester], formed prisms (from ether–ethanol), m. p. 160° (Found: C, 58·1; H, 6·2. $C_{11}H_{14}O_5$ requires C, 58·4; H, 6·25%).

Methyl 3-acetonylsalicylate. A solution of methyl 3-(2,3-dihydroxy-2-methylpropyl)-salicylate (33 mg.) in acetic acid (10 ml.) containing lead tetra-acetate (0·05N) was kept at room temperature. Oxidation was complete after 2 hr. (0·94 mol. consumed), and working-up gave *methyl 3-acetonylsalicylate* (87%), m. p. 57—60°; resublimed, it had m. p. 59—60°, $\nu_{max.}$ (in CCl_4) 1680, 1716, 1729 cm.$^{-1}$ (ε_a 710, 340, 300 l. mole^{-1} cm.$^{-1}$) (Found: C, 63·7; H, 5·7. $C_{11}H_{12}O_4$ requires C, 63·45; H, 5·8%). The *2,4-dinitrophenylhydrazone* formed orange needles (from ethyl acetate–light petroleum), m. p. 150—151° (Found: C, 52·7; H, 4·15; N, 14·5. $C_{17}H_{16}N_4O_7$ requires C, 52·55; H, 4·15; N, 14·45%), $\lambda_{max.}$ (in $CHCl_3$) 365 mμ (log ε 4·36).

We thank Dr. G. Eglinton and Mrs. F. Lawrie (Chemistry Department, University of Glasgow) for infrared measurements.

MEDICAL RESEARCH COUNCIL, CLINICAL CHEMOTHERAPY RESEARCH UNIT,
WESTERN INFIRMARY, GLASGOW, W.1. [*Received, August 27th*, 1962.]

[4] Nummy and Tarbell, *J. Amer. Chem. Soc.*, 1951, **73**, 1500.

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140. *Fatty Acids. Part XI.* The Synthesis of* 9D-*Hydroxyoctadecanoic Acid.*†

By C. D. BAKER and F. D. GUNSTONE.

THE hydroxy-acid present in *Strophanthus* seed oils [1] has been shown to be 9-hydroxyoctadec-*cis*-12-enoic acid by degradation [2] and by synthesis.[3] Since the available evidence does not indicate the absolute configuration of the asymmetric centre an attempt has been made to deduce this by using the procedure by which Serck-Hanssen [4] showed ricinoleic acid to be 12*D*-hydroxyoctadec-*cis*-9-enoic acid.†

(+)-Methyl 3*D*-acetoxy-4-carboxybutanoate [(+)-α-L-acetoxy-γ-methoxycarbonylbutyric acid],‡ prepared according to Serck-Hanssen's directions,[5] has been converted into the hitherto unknown 3*D*-hydroxydodecanoic acid by anodic synthesis with nonanoic acid,

* Part X, *J.*, 1963, 489.

† *D*- refers to the system of Linstead, Lunt, and Weedon (*J.*, 1950, 3333).

‡ This and the other compounds of this Note have the (*S*)-configuration on the convention of Cahn, Ingold, and Prelog (*Experientia*, 1956, **12**, 81).

[1] Gunstone, *J. Sci. Food Agric.*, 1952, **3**, 185; 1953, **4**, 129; Gunstone and Morris, *ibid.*, 1959, **10**, 522.

[2] Gunstone, *J.*, 1952, 1274.

[3] Kennedy, Lewis, McCorkindale, and Raphael, *J.*, 1961, 4945.

[4] Serck-Hanssen, *Chem. and Ind.*, 1958, 1554.

[5] Serck-Hanssen, *Arkiv Kemi*, 1956, **10**, 135.

and thence into 9*D*-hydroxyoctadecanoic acid by anodic synthesis with methyl hydrogen suberate. The optical rotations of the synthetic material and 9-hydroxyoctadecanoic acid produced by hydrogenation of the natural acid were, however, so small that it has not been possible to draw any definite conclusion regarding the identity of these two samples.

The synthetic *D*-acid (m. p. 83·5—84·5°), when mixed with that (m. p. 81—82°) derived from the natural unsaturated acid, melted at 82·5—83·5° and since the (±)-acid is reported to melt in the range of 74—77° by four groups of investigators [6] it is likely that the natural unsaturated acid and the saturated acid produced from it have the *D*-configuration.

Experimental.—(+)-*Methyl* 3D-*acetoxy*-4-*carboxybutanoate*.[5] The (±)-acid ester was resolved with (−)-cinchonidine and the (+)-acid (−)-base salt was found to be dimorphous (m. p. 89° and 138—139°). The lower-melting salt crystallised at 0°, the higher-melting at room temperature. Serck-Hanssen reported only the lower m. p. but a sample supplied by him which had been kept for two years at room temperature melted at 138—139°. The regenerated (+)-hydrogen ester had $[\alpha]_D^{17}$ +6·14° ±0·15° (in $CHCl_3$, *c* 20, 1 dm.), n_D^{23} 1·4456 {lit.,[5] $[\alpha]_D^{25}$ +6·1° ± 0·1° (in $CHCl_3$, *c* 20, 1 dm.), n_D^{20} 1·4474}.

3D-*Hydroxydodecanoic acid*. A solution of (+)-methyl 3*D*-acetoxy-4-carboxybutanoate (5·74 g., 1 mol.) and nonanoic acid (13·5 g., 3 mol.) in methanol (25 ml.) containing sodium (0·06 g.) was electrolysed (0·5 amp.; about 1·12 times theoretical faradays passed) to pH 6—7 in the apparatus previously described (Part X). Insoluble product was removed and the neutralised solution poured into water and extracted with ether. Neutral material remaining after removal of acidic compounds was dissolved in methanol (250 ml.) containing concentrated hydrochloric acid (5 ml.) and concentrated to 60 ml. by distillation at atmospheric pressure during 0·5 hr. This process was repeated with two further portions of methanol (250 ml. each) containing 2·5 ml. and no hydrochloric acid, respectively. The product (9·13 g.), containing methyl hydroxydodecanoate, was shaken overnight with aqueous methanolic potassium hydroxide, and the acidic portion when crystallised from light petroleum (b. p. 40—60°) gave 3D-*hydroxydodecanoic acid* (2·5 g., 37%), m. p. 60—60·5°, $[\alpha]_D^{17}$ −16·1° ± 0·4° (in $CHCl_3$, *c* 5, 1 dm.) (Found: C, 66·5; H, 11·0. $C_{12}H_{24}O_3$ requires C, 66·6; H, 11·2%). The methyl ester had a carbon number [7] of 13·6 on an Apiezon L column in a Pye argon chromatograph.

12D-*Hydroxyoctadecanoic acid*. After treatment with hot acetyl chloride, hydroxydodecanoic acid (2·10 g., 1 mol.) was dissolved, with methyl hydrogen suberate (5·5 g., 3 mol.), in methanol (20 ml.) containing sodium (0·02 g.). The solution was electrolysed (0·75 amp., 1·28 times theoretical faradays passed) to pH 6—7 and the product was isolated as before. The neutral portion (6·02 g.) was a mixture of the desired methyl acetoxyoctadecanoate with tetradecanedioic ester and was separated by taking advantage of the fact that the latter forms a urea inclusion compound more readily than the former. After two treatments with urea, crude methyl acetoxyoctadecanoate (2·91 g.) was obtained. This was hydrolysed with apueous-methanolic potassium hydroxide. The resulting *acid*, crystallised from light petroleum (b. p. 80—100°) and then aqueous methanol, melted at 83·5—84·5° (0·82 g., 28%) (Found: C, 72·2; H, 12·1. $C_{18}H_{36}O_3$ requires C, 72·0; H, 12·1%). This acid melted at 82·5—83·5° when mixed with 9-hydroxyoctadecanoic acid of m. p. 81—82°, obtained by hydrogenation of natural 9-hydroxyoctadec-12-enoic acid, and the two samples had identical infrared spectra. Neither acid showed measurable optical rotation (sodium lamp) and the optical rotatory dispersion curves were not significant. The hydroxy- and the acetoxy-ester had carbon numbers of 19·8 and 19·85, respectively, on an Apiezon L column in a Pye argon chromatograph.

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