NOTES.

The Preparation of Some 1-*Chloroalkane*-1-*carboxylic Acids.*

By R. H. Horn, R. B. Miller, and S. N. Slater.

In the course of a preliminary study of certain aspects of the Darzens glycide ester synthesis, using the esters of chlorinated long-chain fatty acids, it was found that the purity of the chloro-ester is of critical importance. It became necessary therefore to develop a satisfactory method of preparing quantities of authentic 1-chloroalkane-1-carboxylic acids. The work of Guest *et al.* (*J. Amer. Chem. Soc.*, 1944, **66**, 2074; 1947, **69**, 300) has shown that the only satisfactory general method is that involving chlorination of an alkylmalonic acid followed by decarboxylation (Cloves, *Annalen*, 1901, **319**, 357; Staudinger, Anthes, and Schneider, *Ber.*, 1913, **46**, 3539; Blaise, *Bull. Soc. chim.*, 1914, **15**, 666), and our experience confirms this conclusion. By use of this method we have prepared a series of 1-chloroalkane-1-carboxylic and -1 : 1-dicarboxylic acids and their esters, amides, and anilides, the results being summarized in the tables.

1-*Chloroalkane*-1 : 1-*dicarboxylic acids.*

		Cl, %.		Equiv.		
Alkane.	Formula.	Found.	Calc.	Found.	Calc.	M.p.*
Propane	$C_5H_7O_4Cl$	20·9	21·3	81·4	83·2	101—103° (*a*)
Pentane	$C_7H_{11}O_4Cl$	17·9	18·3	97·4	97·2	94—96
Heptane	$C_9H_{15}O_4Cl$	15·7	16·0	111·3	111·2	118—119·5
Nonane	$C_{11}H_{19}O_4Cl$	14·0	14·3	124·2	125·2	95—97
Undecane	$C_{13}H_{23}O_4Cl$	12·7	12·7	140·0	139·2	95—96·5

* M. p.s were taken in a bath preheated to about 5° below the recorded figures.

(*a*) Cloves (*loc. cit.*) gives 102—103°; Blaise (*loc. cit.*) 106—107°; Staudinger *et al.* (*loc. cit.*) 101—102°.

1-*Chloroalkane*-1-*carboxylic acids.*

		Cl, %.		Equiv.				
Alkane.	Formula.	Found.	Calc.	Found.	Calc.	B. p./mm.	n_D^{25}.	d_{25}^{25}.
Propane	$C_4H_7O_2Cl$	28·9	29·2	125·0	122·5	98°/13·5 (*a*)	1·435	1·189
Pentane	$C_6H_{11}O_2Cl$	23·5	23·6	150·8	150·5	122°/12 (*b*)	1·441	1·100
Heptane	$C_8H_{15}O_2Cl$	19·9	19·9	180·0	178·5	155°/10 (*c*)	1·446	1·049

		C, %.		H, %.		Cl, %.		Equiv.			
		Found.	Reqd.	Found.	Reqd.	Found.	Reqd.	Found.	Reqd.	M. p.	B. p./mm.
Nonane	$C_{10}H_{19}O_2Cl$	58·4	58·1	9·28	9·20	17·2	17·3	203·0	206·5	23—25°	165°/10 *
Undecane	$C_{12}H_{23}O_2Cl$	61·8	61·4	10·2	9·81	15·0	15·2	234·3	234·5	35—38°	183—184/10

(*a*) Blaise (*loc. cit.*) gives 109·5°/24 mm.; Cloves (*loc. cit.*) 101°/15 mm.

(*b*) Levene and Haller (*J. Biol Chem.*, 1929, **83**, 591) gives 80—95°/1 mm.; Guest (*loc. cit.*) 102—107°/4 mm.

(*c*) Guest (*loc. cit.*) gives 140—145°/4 mm. * n_D^{25} 1·450; d_{25}^{25} 1·013.

Ethyl esters of 1-*chloroalkane*-1-*carboxylic acids.*

Alkane.	Formula.	C, %. Found.	C, %. Reqd.	H, %. Found.	H, %. Reqd.	B.p./mm.	n_D^{25}.	d_{25}^{25}.
Propane	$C_6H_{11}O_2Cl$	48·0	47·8 *	7·56	7·31 *	56—57°/12 (*a*, *b*)	1·418 (*a*)	1·050 (*a*, *b*)
Pentane	$C_8H_{15}O_2Cl$	53·7	53·8	8·17	8·40	77—78/10	1·426	1·007
Heptane	$C_{10}H_{19}O_2Cl$	58·5	58·1	9·56	9·20	132·5—135/10	1·432	0·982
Nonane	$C_{12}H_{23}O_2Cl$	61·5	61·4	9·88	9·81	136·5—137·5/10	1·436	0·959
Undecane	$C_{14}H_{27}O_2Cl$	64·4	64·0	10·3	10·3	161—165/15 (*c*)	1·439	0·944

(*a*) Henry (*Chem. Zentr.*, 1898, II, 273) gives b. p. 163—164°, *n* 1·4243, d^{18} 1·058.
(*b*) Markownikoff (*loc. cit.*) gives b. p. 156—160°, $d^{17·5}$ 1·063.
(*c*) Darzens (*loc. cit.*) gives 132—133°/4 mm. * Calculated (not " required ") values.

Derivatives of 1-*chloroalkane*-1-*carboxylic acids.*

Alkane.	Amides. Formula.	N, %. Found.	N, %. Reqd.	M. p.	Anilides. Formula.	N, %. Found.	N, %. Reqd.	M. p.
Propane	C_4H_8ONCl	12·0	11·5	75·5—76°	$C_{10}H_{12}ONCl$	7·3	7·1	74—76°
Pentane	$C_6H_{12}ONCl$	9·6	9·4	57·8—58·2				
Heptane	$C_8H_{16}ONCl$	8·0	7·9	70—71				
Nonane	$C_{10}H_{20}ONCl$	6·4	6·8	74—74·5	$C_{16}H_{24}ONCl$	5·1	5·0	38—40
Undecane.....	$C_{12}H_{24}ONCl$	6·2	6·0	79—79·5	$C_{18}H_{28}ONCl$	4·1	4·5	50—52

Experimental.—1-*Chloroalkane*-1 : 1-*dicarboxylic acids.* The appropriate alkane-1 : 1-dicarboxylic acids were readily chlorinated, by the method of Staudinger, Anthes, and Schneider (*loc. cit.*). A typical experiment was as follows: nonane-1 : 1-dicarboxylic acid (80 g.) was dissolved in absolute ether (240 c.c.), and sulphuryl chloride (51 g.) was dropped in. The mixture was heated under reflux for 3 hours, washed with water (5 c.c.), dried, and evaporated. The acid was crystallised from toluene–light petroleum (b. p. 40—70°); yield, 67 g. (71%). If impure benzene or toluene is used in these crystallisations (especially with the lower members of the series), dissolution of the acid is accompanied by strong discoloration: 1-chloropropane-1 : 1-dicarboxylic acid becomes black merely when kept in some samples of cold toluene. The acids were all soluble in water, the higher ones forming gels in concentrated aqueous solution, and the two lowest acids were hygroscopic.

1-*Chloroalkane*-1-*carboxylic acids.* Decarboxylation of the dibasic acids was brought about by heating them at 120—130° for about 1 hour. The products were clean and colourless and of constant b. p. The yields were practically quantitative. The acids had smells similar to those of the corresponding unsubstituted acids, but much fainter. When rubbed on the skin, they caused a delayed burning sensation. Except for the first member they were insoluble in water.

Ethyl esters of 1-*chloroalkane*-1-*carboxylic acids.* These esters were prepared in the usual way by the Fischer–Speier method, the reaction time in all cases being 3 hours. The yields rose steadily from 61% in the case of the lowest member to 97% with the highest.

Derivatives. Despite repeated recrystallisation the anilides of the 1-chloroalkane-1-carboxylic acids failed to give sharp m. p.s. The amides were prepared from the acid chlorides in the usual way, giving clean colourless initial products which on recrystallisation were obtained as white plates of sharp m. p.

The authors are indebted to the Travis Research Trust for the gift of certain chemicals, and to Dr. T. S. Ma for performing the microanalytical determinations of carbon, hydrogen, and nitrogen.—VICTORIA UNIVERSITY COLLEGE, WELLINGTON, NEW ZEALAND; and UNIVERSITY OF OTAGO, DUNEDIN, NEW ZEALAND. [*Received, February* 16*th*, 1950.]

Preparation of Some Derivatives of p-*Hydroxybenzamidine.* By M. W. PARTRIDGE.

INTEREST in derivatives of *p*-hydroxybenzamidine arose from the high activity against *Mycobacterium tuberculosis in vitro* exhibited by certain di-(*p*-*N*-arylamidinophenoxy)alkanes, *p*-alkoxy-*N*-arylbenzamidines (Partridge, *J.*, 1949, 2683, 3043), and *p*-(ω-alkoxyalkoxy)-*N*-arylbenzamidines (Cooper and Partridge, *J.*, 1950, 459). The *N*-substituted amidines were obtained from *p*-cyanophenol by standard methods (Oxley and Short, *J.*, 1946, 147; Partridge and Short, *J.*, 1947, 390). Nitration, bromination, and iodination of *p*-hydroxybenzamidine were employed for the preparation of the corresponding nitro-, dibromo-, and di-iodo-derivatives; hydrolysis of these compounds to the known substituted benzoic acids demonstrated that substitution occurred in the positions *ortho* to the hydroxyl group. Reduction of 3-nitro-4-hydroxybenzamidine afforded 3-amino-4-hydroxybenzamidine.

Biological Results.—The method of testing was that previously described (Partridge, *J.*, 1949, 2683). Apart from *p*-hydroxy-*NN*-diphenylbenzamidine and 3-amino-4-hydroxybenzamidine which inhibited the growth of *M. tuberculosis* at dilutions of 1 : 5000, none of the amidines described here was active at a dilution of 1 : 1000. The absence of activity in *p*-hydroxy-*N*-phenylbenzamidine is of interest since the corresponding *p*-alkoxy-*N*-phenylbenzamidines are active *in vitro*, at dilutions of up to 1 : 5,000,000 in the case of the *p*-hexyloxy-homologue.

Experimental.—p-*Hydroxy*-N-*phenylbenzamidine.* *p*-Cyanophenol (11·9 g.) and anilinium benzenesulphonate (25·1 g., 1 mol.), when heated together at 210° for 1 hour, reacted exothermally. Crystallisation of the cooled melt from aqueous ethanol afforded p-*hydroxy*-N-*phenylbenzamidinium benzenesulphonate* (22 g., 66%), m. p. 183—184° (Found: N, 7·7. $C_{19}H_{18}O_4N_2S$ requires N, 7·6%).

p-*Hydroxy*-NN-*diphenylbenzamidine.* Diphenylamine (8·45 g.) was gradually added to molten anhydrous benzenesulphonic acid (7·9 g., 1 mol.); *p*-cyanophenol (6 g., 1 mol.) was added and the mixture was heated at 210° for 90 minutes. The cooled melt on crystallisation from aqueous ethanol yielded the *amidinium benzenesulphonate* (10·1 g., 45%) as leaflets, m. p. 263—264° (decomp.) (Found:

N, 6·3. $C_{25}H_{22}O_4N_2S$ requires N, 6·3%). The *base*, precipitated by ammonia from an aqueous ethanolic solution of the foregoing salt, crystallised from ethanol with solvent of crystallisation and had m. p 102—104° (decomp.); from ethyl acetate, it separated as prisms, m. p. 200—202° (Found: N, 9·7. $C_{19}H_{16}ON_2$ requires N, 9·9%); the *hydrochloride*, prisms from methanol–acetone, had m. p. 256—257° (decomp.) (Found: N, 8·9. $C_{19}H_{17}ON_2Cl$ requires N, 8·7%); the *picrate* had m. p. 252—253° (Found: N, 13·5. $C_{25}H_{19}O_8N_5$ requires N, 13·6%).

p-*Hydroxy*-N-p′-*nitrophenylbenzamidine* was obtained as its *benzenesulphonate* by heating *p*-cyanophenol (5·95 g.) and *p*-nitroanilinium benzenesulphonate (14·8 g., 1 mol.) at 190° for 75 minutes and crystallising the product from water; the yield was 14·8 g. (71%), and the m. p. 262—264° (decomp.) (Found: N, 10·15. $C_{19}H_{17}O_6N_3S$ requires N, 10·1%).

p-*Hydroxy*-N-*methylbenzamidine*. The product obtained by heating together *p*-cyanophenol (11·9 g.) and methylammonium thiocyanate (9 g., 1 mol.) for 3 hours at 180° was dissolved in hot water (10 c.c.) and poured into aqueous ammonia (*d* 0·880; 20 c.c.); p-*hydroxy*-N-*methylbenzamidine dihydrate* (10·8 g., 53%), which separated, was obtained as needles (from water), m. p. 260—261° (decomp.) (Found: N, 13·9, 13·8. $C_8H_{10}ON_2,2H_2O$ requires N, 13·85%). The *nitrate*, m. p. 170—171° (decomp.), crystallised as needles from water (Found: N, 19·5. $C_8H_{11}O_4N_3$ requires N, 19·7%); the *picrate*, crystallised from aqueous methanol, had m. p. 217—218° (decomp.) (Found: N, 18·6. $C_{14}H_{13}O_8N_5$ requires N, 18·5%).

3-*Nitro*-4-*hydroxybenzamidine*. Finely powdered *p*-hydroxybenzamidinium nitrate (2 g.) (Partridge and Short, *loc. cit.*), added during 15 mins. to ice-cold concentrated sulphuric acid (4 c.c.), was kept at 0° for 30 minutes and at 20° for 90 minutes. Material, precipitated at 0° by the addition of aqueous ammonia, afforded, on neutralisation to Congo-red with aqueous benzenesulphonic acid and crystallisation from water, 3-*nitro*-4-*hydroxybenzamidinium benzenesulphonate* (1·9 g., 56%) as pale brown prisms, m. p. 162° (Found: N, 12·6. $C_{13}H_{13}O_6N_3S$ requires N, 12·4%). A further quantity was obtained from the mother-liquors as the *picrate* (1·1 g., 35%), needles (from aqueous 2-ethoxyethanol), m. p. 258—260° (decomp.) (Found: N, 20·6. $C_{13}H_{10}O_{10}N_6$ requires N, 20·5%). Only unchanged *p*-hydroxybenzamidine was recovered in attempts to carry out this nitration in glacial acetic acid.

Hydrolysis of this amidine by boiling with 2N-sodium hydroxide for 90 minutes gave a 92% yield of 3-nitro-4-hydroxybenzoic acid, m. p. 184—185°, not depressed on admixture with an authentic specimen (Griess, *Ber.*, 1887, **20**, 408).

3 : 5-*Dibromo*-4-*hydroxybenzamidine*. *p*-Hydroxybenzamidine dihydrate (1 g.), suspended in water (10 c.c.) and neutralised to Congo-red with aqueous hydrobromic acid, was treated at 0°, during 10 minutes, with bromine (2·5 g. dissolved in 25 c.c. of 15% aqueous potassium bromide; 2·7 mols.) and kept at 20° for 30 minutes. The precipitate (1·75 g., 80%), m. p. 290—292° (decomp.), afforded pure 3 : 5-*dibromo*-4-*hydroxybenzamidinium bromide*, as needles, m. p. 293—294° (decomp.), from N-hydrobromic acid (Found: N, 7·5; Br, 63·5. $C_7H_6ON_2Br_2,HBr$ requires N, 7·5; Br, 64·0%). The *picrate*, m. p. 312—314° (decomp.), crystallised from aqueous 2-ethoxyethanol (Found: N, 13·1. $C_{13}H_9O_8N_5Br_2$ requires N, 13·4%). Hydrolysis of the foregoing amidine by boiling 2N-sodium hydroxide afforded 3 : 5-dibromo-4-hydroxybenzoic acid, m. p. 267—268° (decomp.), not depressed on admixture with the compound prepared according to Robertson (*J.*, 1902, **81**, 1482).

3 : 5-*Di-iodo*-4-*hydroxybenzamidine*. *p*-Hydroxybenzamidine dihydrate (5·16 g.), dissolved in 5N-sulphuric acid (13 c.c., 1·1 mols.) at 60°, was treated during 90 minutes with a solution of potassium iodide (3·32 g., 0·66 mol.) and potassium iodate (3·21 g., 0·5 mol.) in water (80 c.c.). The precipitate, on crystallisation from aqueous benzenesulphonic acid, afforded 3 : 5-*di-iodo*-4-*hydroxybenzamidinium benzenesulphonate* (5·3 g., 57%) which after recrystallisation from ethanol–*n*-butanol had m. p. 240—241° (decomp.), iodine being evolved at 236° (Found: N, 5·25; I, 46·2. $C_{13}H_{12}O_4N_2I_2S$ requires N, 5·15; I, 46·5%). *p*-Hydroxybenzamidine (40%) was recovered from the mother-liquors from the iodination.

3 : 5-Di-iodo-4-hydroxybenzoic acid (96%) was obtained on hydrolysis of the foregoing amidine by boiling 2N-sodium hydroxide. The m. p. of this acid, 248—249° (decomp.) (cf. Henry and Sharp, *J.*, 1922, **121**, 1059), was undepressed by the authentic compound (*Org. Synth.*, 1934, **14**, 53).

3-*Amino*-4-*hydroxybenzamidine*. 3-Nitro-4-hydroxybenzamidine (5·5 g.) was refluxed for 1 hour with stannous chloride (22 g., 3·6 mols.), concentrated hydrochloric acid (36 c.c.), and tin (12·3 g., 3·4 mols.), and the liquid was filtered and partly neutralised with aqueous ammonia. After removal of tin by hydrogen sulphide, the dihydrochloride was salted out with concentrated hydrochloric acid; the yield was 4 g. (51%), and the m. p. 290° (decomp.); Andrewes, King, and Walker (*Proc. Roy. Soc., B*, 1946, **133**, 30) record m. p. 292° (efferv.). The mother-liquors, after neutralisation, afforded the *dipicrate* (2·6 g., 14%), which crystallised as needles (from water), m. p. 210—212° (decomp.) (Found: N, 20·5. $C_{19}H_{15}O_{15}N_9$ requires N, 20·7%).

Reduction with zinc dust in neutral solution gave a 48% yield of the amino-amidine, identified as the dipicrate and as the neutral *sulphate*, which formed colourless needles, m. p. 266—267° (decomp.), on crystallisation from dilute sulphuric acid (Found: N, 16·6. $C_7H_9ON_3,H_2SO_4$ requires N, 16·85%). Iron-reduction afforded 53% of the amino-amidine which was characterised as the dipicrate and neutral sulphate.

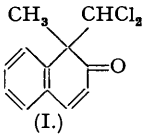
NN′-*Di*-p-*hydroxyphenylformamidine*. Ethyl orthoformate (14·8 g.) and *p*-aminophenol (21·8 g., 2 mols.) were heated together at 100° for 1 hour. Crystallisation of the resulting resin from *iso*propanol afforded the *formamidine* (7·2 g., 25%) which melted with effervescence at 120—130°, solidified, and again melted at 188—189° (decomp.) (Found: N, 9·7. $C_{13}H_{12}O_2N_2,C_3H_6O$ requires N, 9·7%). The *hydrochloride*, which crystallised as needles from dilute hydrochloric acid, sintered at 105—110°, began to decompose at 207°, and melted at 237—238° (Found: N, 9·4. $C_{13}H_{12}O_2N_2,HCl,2H_2O$ requires N, 9·3%).

The author gratefully acknowledges his indebtedness to Mr. C. E. Coulthard, Dr. L. Dickinson, and Miss B. Croshaw for the biological tests.—RESEARCH LABORATORIES, MESSRS. BOOTS PURE DRUG CO., LTD., NOTTINGHAM. UNIVERSITY OF NOTTINGHAM. [*Received, March 8th*, 1950.]

The Reactivity of β-Naphthols and β-Naphthylamines. By. F. BELL and W. H. HUNTER.

MANY papers have dealt with the low reactivity of the 3-position in β-naphthols and β-naphthylamines and the following experiments still further exemplify this point.

Reimer–Tiemann Reaction with 1-Methyl-2-naphthol.—1-Methyl-2-naphthol (10 g.; Robinson and Weygand, *J.*, 1941, 387) was added to sodium hydroxide (18·2 g.) dissolved in water (38 c.c.) and ethanol (30 c.c.). The mixture was heated to 70° on the water-bath, and chloroform (11·5 g.) added dropwise with stirring during 30 minutes. The stirring was continued for 1 hour, and the contents of the flask were cooled and made acid with concentrated hydrochloric acid (*ca.* 20 c.c.). The dark oil which separated was extracted with ether, dried, and distilled *in vacuo*, yielding 8·7 g. of a pale yellow oil, b.p. 130—132°/2 mm. The oil solidified when kept for several days, yielding prisms of 2-*keto*-1-*methyl*-1-*dichloromethyl*-1 : 2-*dihydronaphthalene* (I), m.p. 65°, more expeditiously obtained by vigorous scratching of the oil with 50% alcohol (Found : C, 59·8; H, 4·0. $C_{12}H_{10}OCl_2$ requires C, 59·8; H, 4·1%). The ketone did not yield an oxime, semicarbazone, or phenylhydrazone.


(I.)

Reimer–Tiemann Reaction with 1-Ethyl-2-naphthol.—1-Ethyl-2-naphthol was prepared in 38% yield by Clemmensen reduction of 1-acetyl-2-naphthol in toluene (cf. Imoto, *J. Chem. Soc. Japan*, 1937, **58**, 932). In the Reimer–Tiemann reaction it yielded an oil, b.p. 140—142°/0·2 mm., which was similar to the above but did not solidify and could not be obtained pure.

Attempted Coupling of 1-Methyl-2-naphthol with Diazotised Picramide.—1-Methyl-2-naphthol in glacial acetic acid was added to diazotised picramide (Misslin, *Helv. Chem. Acta*, 1920, **3**, 626) at 0° to −3°. Stirring was continued for 1 hour, and the mixture poured on ice, but essentially unchanged 1-methyl-2-naphthol was precipitated.

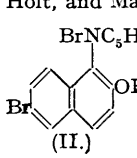
Nitration of 1-Bromo-2-toluene-p-sulphonamidonaphthalene in Pyridine (method of Battegay and Brandt, *Bull. Soc. chim.*, 1922, **31**, 910).—Freshly distilled nitrobenzene (120 c.c.) and pyridine (75 c.c.) were mixed and cooled to 0°, and nitric acid (7·5 c.c.; *d* 1·51) added. Nitrogen peroxide was removed by a current of air, and 1-bromo-2-toluene-*p*-sulphonamidonaphthalene (37 g.) added. The solution was heated in an oil-bath at 60° for 2 hours and then to 120° for 2 hours, considerable quantities of nitrogen peroxide then being evolved. The cooled mixture was poured into water and made alkaline, and the nitrobenzene removed in steam. The residual yellow liquid was decanted from a little tar and made acid. 1-Bromo-6-nitro-2-toluene-*p*-sulphonamidonaphthalene (34 g.) was precipitated (m. p. 195° alone or mixed with an authentic sample).

1-*Bromo*-2-*N*-*methylnaphthylamine.*—To 2-N-methylnaphthylamine (Pschorr and Karo, *Ber.*, 1906, **39**, 3141) (50 g.) in chloroform (500 c.c.), cooled in ice, bromine (51 g.) in chloroform (50 c.c.) was slowly added. The mixture was left overnight, and the hydrobromide of 1-bromo-2-*N*-methylnaphthylamine (56 g.) separated. This was decomposed by 10% ammonia solution, and the liberated oil shaken until solid. 1-*Bromo*-2-*N*-*methylnaphthylamine* crystallised from methanol, ethanol, or light petroleum in white leaflets, m. p. 46° (34 g.) (Found : C, 56·1; H, 4·2. $C_{11}H_{10}NBr$ requires C, 56·0; H, 4·2%). The *hydrochloride*, precipitated from ether solution by hydrogen chloride, formed white needles, m. p. 178° (decomp.) decomposed by water (Found : equiv., 277. $C_{11}H_{10}NBr,HCl$ requires equiv., 273); the *benzoyl* derivative, formed white needles, m. p. 111°, from ethanol (Found : C, 63·6; H, 4·6. $C_{18}H_{14}ONBr$ requires C, 63·7; H, 4·2%).

1-*Bromo*-N-*nitroso*-2-N-*methylnaphthylamine.*—Sodium nitrite solution (30 c.c.; 10%) was slowly added to a vigorously stirred solution of the amine (10 g.) in hydrochloric acid (6 c.c. in 150 c.c. of water). The precipitated red solid on recrystallisation from 60% ethanol gave the *nitroso*-compound as pinkish leaflets, m. p. 119—120° (8·4 g., 80%) (Found : C, 50·1; H, 3·6. $C_{11}H_9ON_2Br$ requires C, 49·8; H, 3·4%).

Attempts to cause Migration of the Nitroso-group in 1-Bromo-N-nitroso-2-N-methylnaphthylamine.—(*a*) The nitrosoamine (2 g.) was suspended in absolute alcohol (10 c.c.), and saturated absolute alcoholic hydrogen chloride (10 c.c.) added at −5° with stirring. After being left for 4 days at −5°, the nitrosoamine was recovered unchanged in 75% yield, and no basic material could be isolated. (*b*) Repetition of this procedure, sufficient alcohol being used for dissolution, resulted only in formation of 1-bromo-2-*N*-methylnaphthylamine. With glacial acetic acid as solvent the same result was obtained.

3-*Chloro*-2-*naphthol.*—3-Chloro-2-naphthol is stated to have m. p. 63—64·5° when prepared from 3-hydroxy-2-naphthoic acid *via* 3-chloro-2-methoxynaphthalene (Jambuserwala, Holt, and Mason, *J.*, 1931, 374), whereas prepared by chlorination of α-nitroso-β-naphthol it has m. p. 90° (Marschalk, *Bull. Soc. chim.*, 1928, **43**, 1361). Marschalk's result is now confirmed. 3-Chloro-2-methoxynaphthalene, prepared from Marschalk's 3-chloro-2-naphthol, proved identical with that obtained by Jambuserwala, Holt, and Mason's method. Demethylation of the methoxy-compound by hydriodic acid did not proceed smoothly and mixtures were obtained from which a pure phenol could not be isolated. This difficulty in demethylating 3-substituted 2-naphthyl ethers has been reported also by Clemo and Spence (*J.*, 1928, 2819). The correct m. p. of 3-chloro-2-naphthol is, therefore, 90°, and Marschalk's experiment provides one of the few examples of group entry in position 3.

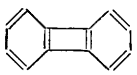

(II.)

Bromination of 1-Bromo-2-naphthol in Pyridine.—This led only to the isolation of (II), previously obtained by Fries and Schimmelschmidt (*Annalen*, 1930, **484**, 245) from the interaction of 1 : 1-dibromo-2-keto-1 : 2-dihydronaphthalene with pyridine. Similar high-melting, nitrogen-containing compounds were obtained by interaction of both 1-methyl-2-naphthol and 2 : 2′-dihydroxy-1 : 1′-dinaphthyl with bromine in pyridine.

One of the authors (W. H. H.) gratefully acknowledges the receipt of a grant from the Department of Scientific and Industrial Research.—COLLEGE OF TECHNOLOGY, BELFAST. [*Received, May 22nd*, 1950.]

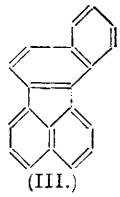
Dinaphthylenes. By F. BELL and W. H. HUNTER.

ALTHOUGH *o*-diphenylene (I) has been the subject of much study on account of the *cyclo*butadiene system which it contains, the closely related dinaphthylenes (II and isomers) have been comparatively neglected. Von Braun and Kirschbaum (*Ber.*, 1921, **54**, 597) obtained from 1 : 2-dihydronaphthalene with sulphuric acid a bisdialin which on distillation with lead oxide gave a yellow powder, m. p. 165°, of composition $C_{20}H_{12}$. The same compound can be obtained by the selenium dehydrogenation of the hydrocarbon, $C_{20}H_{20}$, obtained by interaction of tetralin with aluminium chloride (Dansi and Ferri, *Gazzetta*, 1941, **71**, 648; Dansi and Reggiani, *ibid.*, 1948, **78**, 801). Orchin and Reggel (*J. Amer. Chem. Soc.*, 1947, **69**, 505) by pyrolysis of 1 : 2′-dinaphthyl obtained a mixture of two benzfluoranthenes, one, m. p. 166°, apparently identical with the above material, and the other, m. p. 217°, identical with 11 : 12-benzfluoranthene synthesised from acenaphthenequinone by Moureu (*Bull. Soc. chim.*, 1948, **15**, 99). It appears therefore that the hydrocarbon, $C_{20}H_{12}$, is a 10 : 11-benzfluoranthene (III) and not a dinaphthylene.

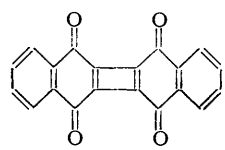


(I.)

(II.)



(III.)



(IV.)

Rosenhauer, Braun, Pummerer, and Riegelbauer (*Ber.*, 1937, **70**, 2281) obtained from α-naphthaquinone a compound to which they assigned the structure (IV), and from this, by distillation with zinc dust, a hydrocarbon, m. p. 365°, to which the formula (II) was ascribed. Although it is easy to obtain (IV), we have failed to convert it into a hydrocarbon by distillation with zinc dust under various conditions.

The most direct route to the dinaphthylenes appeared to be the linking of two molecules of a 1 : 2- or 2 : 3-dibromonaphthalene by the Ullmann or the Grignard–cupric chloride reaction. However, the only product from the Ullmann reaction was an uncrystallisable tar, whilst the interaction of both atoms of a dibromonaphthalene with magnesium could not be realised, one half of the magnesium being unattacked. A similar failure to prepare a Grignard compound from *p*-dibromobenzene was reported by Pink (*J.*, 1923, **123**, 3418).

The interaction of 1 : 2-dibromonaphthalene with naphthalene under the influence of aluminium chloride or of 1 : 2- and 2 : 3-dibromonaphthalenes with sodium or potassium yielded no useful result.

The attempted twofold linking of naphthalene derivatives having met with no success, the formation of a second linkage between the two nuclei of a dinaphthyl was attempted. Ring closure of 1-bromo-2 : 2′-dinaphthyl by means of aluminium chloride in various solvents and the reaction of 1 : 1′-dibromo-2 : 2′-dinaphthyl with copper and with sodium were investigated without result.

The Pschorr reaction on diazotised 1-amino-2 : 2′-dinaphthyl appeared a possible route. The base has been described by Cumming and Howie (*J.*, 1933, 532) but repetition of their experiment gave only 1 : 2 : 7 : 8-dibenzcarbazole, previously prepared by Vesely (*Ber.*, 1905, **38**, 139) by reduction of 1 : 1′-dinitro-2 : 2′-dinaphthyl (cf. Huisberg and Sorge, *Annalen*, 1950, **566**, 162). Variations of the reduction method (tin, stannous chloride, aluminium amalgam) yielded the carbazole, as with zinc dust, but on prolonging the original zinc dust reduction elimination of the nitro-group took place and 2 : 2′-dinaphthyl was obtained.

1-*Bromo*-2 : 2′-*dinaphthyl*.—2 : 2′-Dinaphthyl (10 g.) and *N*-bromosuccinimide (7·5 g.) were refluxed for 8 hours in dry chloroform (200 c.c.). The mixture, after filtration from succinimide, was evaporated, and the residue crystallised from ethanol, giving needles, m. p. 123° (Found : C, 72·2; H, 3·9. $C_{20}H_{13}Br$ requires C, 72·5; H, 3·9%). Monobromination could not be achieved directly.

1-*Nitro*-2 : 2′-*dinaphthyl*.—2 : 2′-Dinaphthyl (10 g.) was dissolved in acetic acid (180 c.c.) and quickly cooled. Nitric acid (6 c.c.; *d* 1·52) was added, and the mixture heated on a steam-bath for 2 hours. The crystals of 2 : 2′-dinaphthyl gradually disappeared, giving a yellow solution which deposited yellow needles on cooling. Recrystallisation from acetic acid gave 1-nitro-2 : 2′-dinaphthyl (8·4 g.), m. p. 179°. The directions of Cumming and Howie (*J.*, 1931, 3180) led to a negligible yield of this nitro-compound.

We believe that a true dinaphthylene has still to be described.—COLLEGE OF TECHNOLOGY, BELFAST. [*Received, May 24th*, 1950.]

2- *and* 4-*Nitro*-3-*aminocarbazole.* By GEORGE ANDERSON and NEIL CAMPBELL.

KEHRMAN and ZWEIFEL (*Helv. Chim. Acta*, 1928, **11**, 1213) by nitration of the diacetyl and triacetyl derivatives of 3-aminocarbazole obtained products which on hydrolysis gave two isomers, m. p. 233° and 177°, and were termed α- and β-nitro-3-aminocarbazole, respectively. We have now shown that the α-compound is the 2-nitro-compound since it yielded by the diazo-reaction 2-nitrocarbazole identical with an authentic sample prepared from 7-nitro-1 : 2 : 3 : 4-tetrahydrocarbazole (Barclay and Campbell, *J.*, 1945, 530). The β-compound is therefore 4-nitro-3-aminocarbazole. On this basis the following m. p.s may be assigned. 2-Nitro-3-diacetylamino-, m. p. 226°, 2-nitro-3-acetamido-, m. p. 275°, 4-nitro-3-acetamidocarbazole, m. p. 198°.

Information on 2-aminocarbazole is scanty and incomplete. Blank (*Ber.*, 1891, **24**, 306) by the pyrolysis of " diphenylin," presumably 2 : 4′-diaminodiphenyl, obtained a product, m. p. 238°, which he considered to be 2-aminocarbazole but for which he did not record an analysis. King and King

(*J.*, 1945, 824) obtained a product, m. p. 240°, from 3-acetamidobenzocinnoline, which they believed to be 2-aminocarbazole. It has been claimed that the compound is obtained by heating 2 : 2′ : 4′-triaminodiphenyl-4-sulphonic acid with dilute acid followed by removal of the sulphonic group (G.P. 542,422), but no m. p. or analysis was given. It was therefore decided to repeat Blank's work, and the product obtained was found to be identical with 2-aminocarbazole obtained by the reduction of 2-nitrocarbazole (Barclay and Campbell, *loc. cit.*).

Experimental.—Nitration of acetylated 3-aminocarbazole. Reduction of 3-nitro- to 3-amino-carbazole was best effected by hydrogenation in ethanol with Adams's platinum catalyst. Reduction with stannous chloride–hydrochloric acid (Kehrmann and Zweifel, *loc. cit.*) or ethanolic potassium hydroxide (Whitner, *J. Amer. Chem. Soc.*, 1924, **46**, 2326) gave yields of 25 and 50%, respectively. Excess of acetic anhydride was added to 3-aminocarbazole (5 g.) dissolved in acetic acid, and after several hours the mixture was poured into water. 3-Acetamidocarbazole separated and crystallised from ethanol, formed prisms, m. p. 215° (3·5 g.). 3-Acetamidocarbazole (10 g.) was boiled with acetic anhydride (50 ml.) and sulphuric acid (0·5 ml.) for 45 minutes and then poured into water; the resulting solid was purified by extraction with benzene. Evaporation of the solvent gave a mixture of diacetyl- and triacetyl-3-aminocarbazole as a yellow crystalline solid (11 g.), m. p. 145—165°. Nitration of this mixture was effected by Kehrmann and Zweifel's method (*loc. cit.*). 2-Nitro-3-diacetylaminocarbazole, m. p. 226°, separated first, followed by a mixture of 2-nitro- and 4-nitro-3-diacetylaminocarbazole. This mixture (4 g.) was ground with concentrated ethanolic sodium hydroxide until, on addition of a drop of the mixture to water, no yellow solid resulted. The mixture on filtration gave a filtrate (*A*) and 2-nitro-3-acetamidocarbazole as red needles, m. p. 275°, which when heated with ethanol–hydrochloric acid (equal volumes) followed by treatment with ammonia gave 2-nitro-3-aminocarbazole (1·8 g.), violet needles (from ethanol), m. p. 233°. Attempts to isolate 4-nitro-3-acetamidocarbazole from the filtrate (*A*) were only partly successful (cf. Kehrmann and Zweifel, *loc. cit.*). Chromatographic separation was complicated by hydrolysis of the acetyl compounds on the column. The best separation was effected by grinding the mixture of nitro-compounds (5 g.) for 15 minutes with concentrated sodium hydroxide, filtering off the 2-nitro-3-acetamidocarbazole, and pouring the filtrate into water. Filtration gave a filtrate (*B*) and a residue which crystallised from ethanol in yellow elongated prisms, m. p. 224°, depressed on admixture with 2-nitro-3-diacetylaminocarbazole. It was assumed to be *4-nitro-3-diacetylaminocarbazole* (Found : C, 61·7; H, 3·9. $C_{16}H_{13}O_4N_3$ requires C, 61·7; H, 4·2%). Reduction of the volume of the filtrate (*B*) gave 4-nitro-3-acetamidocarbazole, which crystallised from ethanol in brown needles (1·5 g.), m. p. 198°. Hydrolysis with ethanol–hydrochloric acid yielded 4-nitro-3-aminocarbazole, deep red needles, m. p. 175—177° (lit., 177°).

2- and 4-Nitrocarbazoles. 2-Nitro-3-aminocarbazole, m. p. 233° (0·2 g.), was dissolved in boiling ethanol and 0·3 g. of 20% ethanolic sulphuric acid was added. Diazotisation at 0° with sodium nitrite (0·08 g.) in water (0·14 g.) gave a clear solution which was boiled for 30 minutes and evaporated to a small volume. Addition of water to the hot solution until it was turbid, and cooling gave 2-nitrocarbazole, yellow needles (from benzene, charcoal), m. p. 173°, giving no depression when mixed with an authentic sample and a 20° depression with 4-nitrocarbazole. 4-Nitro-3-aminocarbazole likewise yielded 4-nitrocarbazole, which after chromatographic purification on alumina followed by sublimation was obtained in small yield as yellowish-orange plates, m. p. 179—180°, undepressed when mixed with an authentic sample.

2-Aminocarbazole. (*a*) 2-Nitrocarbazole (0·2 g.) in ethanol (100 ml.) was quickly hydrogenated at 60 lb. pressure with Adams's platinum catalyst. Evaporation of part of the solvent gave 2-aminocarbazole, which crystallised as unstable colourless needles (0·04 g.), m. p. 238—239° (Found : C, 78·3; H, 5·7; N, 14·9. Calc. for $C_{12}H_{10}N_2$: C, 78·1; H, 5·5; N, 15·4%). It gave characteristic colours with mixtures of nitric and sulphuric acids, or sulphuric and selenious acids. 3- and 4-Nitrocarbazoles similarly yielded 3- and 4-aminocarbazoles, but the latter could not be purified. It gave with acetyl chloride and pyridine the *acetyl* derivative, obtained after chromatography on alumina and crystallisation from light petroleum as colourless needles, m. p. 183—185° (Found : C, 75·3; H, 6·0; N, 12·3. $C_{14}H_{12}ON_2$ requires C, 75·0; H, 5·4; N, 12·5%).

(*b*) 2 : 4′-Dinitrodiphenyl (5 g.) was hydrogenated in ethanol (300 ml.) with Adams's platinum catalyst (0·1 g.) at 60 lb. pressure. Removal of the solvent gave 2 : 4′-diaminodiphenyl as an oil which was mixed with lime and pyrolysed in a glass tube 18 in. long, packed loosely with lime and heated to redness. A brown liquid was obtained which crystallised first from ethanol, then from benzene–light petroleum in colourless needles, m. p. 238° alone or admixed with 2-aminocarbazole prepared as above (Found : C, 79·1; H, 5·6; N, 15·0).—UNIVERSITY OF EDINBURGH. [*Received, June 13th*, 1950.]

Sulphanilyl Derivatives of 2-Amino-3 : 6-di-sec.-butylpyrazine. By G. T. NEWBOLD.

IN connection with investigations on the structure of aspergillic acid (see Dunn, Gallagher, Newbold, and Spring, *J.*, 1949, S126, for summary) a method for the synthesis of 2-amino-3 : 6-di-*sec.*-butylpyrazine was developed (Newbold and Spring, *J.*, 1947, 373). Starting from this latter compound the preparation of 3 : 6-di-*sec.*-butyl-2-sulphanilamido- (I), 3 : 6-di-*sec.*-butyl-2-N^4-(hydrogen succinoyl)sulphanilamido- (II), and 3 : 6-di-*sec.*-butyl-2-N^4-(hydrogen phthaloyl)sulphanilamido-pyrazine (III) is described. Some *in vitro* antibacterial tests on these compounds are reported in the Table.

Minimal inhibitory concn. in mg. per 100 c.c. of medium.

	Strep. hæm. :		*Staph aureus* :	*B. coli* :	
Compound.	broth.	blood.	broth.	broth.	synthetic.
(I)	2	>2	>5	>5	>5
(II)	5	>2	>5	>5	>5
(III)	>2	—	>2	>2	>2

Experimental.—2-N⁴-*Acetylsulphanilamido*-3 : 6-*di*-sec.-*butylpyrazine.* Acetylsulphanilyl chloride (1·05 g.) was added in small portions to a cooled solution of 2-amino-3 : 6-di-*sec.*-butylpyrazine (0·9 g.) in dry pyridine (2 c.c.). The reaction mixture was heated on the water-bath for 1 hour, cooled, and poured into water (20 c.c.). The reaction product was collected and crystallised from aqueous ethanol from which 2-N⁴-*acetylsulphanilamido*-3 : 6-*di*-sec.-*butylpyrazine* (1·1 g.) separated as needles, m. p. 187—189° (Found : C, 59·9; H, 6·8; N, 14·1. $C_{20}H_{28}O_3N_4S$ requires C, 59·4; H, 6·9; N, 13·9%).

3 : 6-*Di*-sec.-*butyl*-2-*sulphanilamidopyrazine.* The acetyl compound (0·5 g.), dissolved in a mixture of hydrochloric acid (*d* 1·19; 10 c.c.) and ethanol (50%; 10 c.c.), was heated on the water-bath for 1½ hours. The reaction mixture from which a crystalline solid had separated was cooled and filtered. The filtrate was evaporated to dryness under reduced pressure and the residue combined with the crystalline solid and dissolved in dilute aqueous alkali, the solution then being made just acid with acetic acid. The precipitated 3 : 6-*di*-sec.-*butyl*-2-*sulphanilamidopyrazine* (0·40 g.) crystallised from aqueous ethanol as needles, m. p. 161° (Found : C, 59·9; H, 7·2; N, 15·3. $C_{18}H_{26}O_2N_4S$ requires C, 59·7; H, 7·2; N, 15·5%).

3 : 6-*Di*-sec.-*butyl*-2-p-*succinimidobenzenesulphonamidopyrazine.* 2-Amino-3 : 6-di-*sec.*-butylpyrazine (1·0 g.) in dry pyridine (5 c.c.) was treated with *p*-succinimidobenzenesulphonyl chloride (1·35 g.; Adams, Long, and Jeans, *J. Amer. Chem. Soc.*, 1939, **61**, 2346; Moore and Miller, *ibid.*, 1942, **64**, 1572; Picard, Reid, and Seymour, *J.*, 1946, 751) added during 15 minutes, and the reaction mixture heated on the water-bath for 1 hour. The dark reaction mixture was treated with ice-water; the oily product solidified on storage. The solid was thrice crystallised from ethanol (charcoal), giving 3 : 6-*di*-sec.-*butyl*-2-p-*succinimidobenzenesulphonamidopyrazine* (1·0 g.) as blades, m. p. 179—181° (Found : C, 59·1; H, 6·6; N, 12·8. $C_{22}H_{28}O_4N_4S$ requires C, 59·5; H, 6·3; N, 12·6%).

3 : 6-*Di*-sec.-*butyl*-2-*sulphanilamidopyrazine from* 3 : 6-*di*-sec.-*butyl*-2-p-*succinimidobenzenesulphonamidopyrazine.* The compound (100 mg.) in ethanol (1 c.c.), hydrochloric acid (*d* 1·19; 2 c.c.), and water (1 c.c.) was heated on the water-bath for 75 minutes. The solution was cooled, made just acid with dilute acetic acid, and after some time the precipitate was collected. Crystallisation from aqueous ethanol gave needles (60 mg.), m. p. 161° alone or when admixed with 3 : 6-di-*sec.*-butyl-2-sulphanilamidopyrazine.

3 : 6-*Di*-sec.-*butyl*-2-N⁴-(*hydrogen succinoyl*)*sulphanilamidopyrazine.* (*a*) The succinimido-compound (0·5 g.) was heated under reflux for 2 hours with sodium hydroxide solution (2N.; 5 c.c.), water (20 c.c.), and ethanol (25 c.c.). The solution was concentrated under reduced pressure to small bulk and acidified with acetic acid, and the precipitate collected. Three crystallisations from aqueous ethanol gave 3 : 6-*di*-sec.-*butyl*-2-N⁴-(*hydrogen succinoyl*)*sulphanilamidopyrazine* (0·45 g.) as felted needles, m. p. 200° (Found : C, 57·4; H, 6·1; N, 11·8. $C_{22}H_{30}O_5N_4S$ requires C, 57·1; H, 6·5; N, 12·1%).

(*b*) Succinylsulphanilyl chloride (0·65 g.; Picard, Reid, and Seymour, *loc. cit.*) was added in portions with shaking to an ice-cooled solution of 2-amino-3 : 6-di-*sec.*-butylpyrazine (0·45 g.) in dry pyridine (3 c.c.), and the mixture heated on the water-bath for 1 hour. The yellow solution was poured into ice-water (20 c.c.), the oil which separated extracted with ether (20 c.c.), and the ethereal extract (A) washed with sodium hydroxide solution (2N.; 2 c.c.). The alkaline extract was acidified with acetic acid and kept at 0°. The solid which separated was crystallised from aqueous methanol to give the hydrogen succinoyl derivative (45 mg.) as felted needles, m. p. 200° alone or when mixed with preparation (*a*) above. The ethereal solution (A) was washed with water (3 × 10 c.c.), dried (Na_2SO_4), and evaporated. The residual oil on treatment with ethanolic picric acid gave 2-amino-3 : 6-di-*sec.*-butylpyrazine picrate (0·55 g.), m. p. 131—133°, not depressed by an authentic specimen prepared after Newbold and Spring (*loc. cit.*).

(*c*) 3 : 6-Di-*sec.*-butyl-2-sulphanilamidopyrazine (250 mg.) in acetone (20 c.c.) was treated with succinic anhydride (70 mg.), and the solution refluxed for 1 hour. The acetone was removed and the residue crystallised from aqueous methanol to give the hydrogen succinoyl derivative (300 mg.) as felted needles, m. p. 200° alone or admixed with preparations (*a*) and (*b*).

3 : 6-*Di*-sec.-*butyl*-2-N⁴-(*hydrogen phthaloyl*)*sulphanilamidopyrazine.* 3 : 6-Di-*sec.*-butyl-2-sulphanilamidopyrazine (250 mg.) in acetone (10 c.c.) was treated with a solution of phthalic anhydride (100 mg.) in acetone (15 c.c.) and the solution refluxed for 2 hours. The acetone was distilled off and the residue crystallised from aqueous ethanol to give 3 : 6-*di*-sec.-*butyl*-2-N⁴-(*hydrogen phthaloyl*)*sulphanilamidopyrazine* as needles (320 mg.), m. p. 186—188° (Found : C, 61·0; H, 5·8; N, 11·1. $C_{26}H_{30}O_5N_4S$ requires (C, 61·2; H, 5·9; N, 11·0%).

The author is indebted to Professor F. S. Spring for his interest and encouragement and to Dr. James Walker for making the antibacterial results available.—The Royal Technical College, Glasgow. [*Received, June 15th*, 1950.]

Preparation of Benzylsuccinic Acid from Ethyl α-Methylcinnamate. By W. F. Beech and N. Legg.

Ethyl α-methylcinnamate was brominated with *N*-bromosuccinimide by the Wohl–Ziegler method. The bromo-compound reacted readily with *cyclo*hexylamine, and examination of the ultra-violet absorption spectrum ($\lambda_{max.}$ = 281 mμ.; $\varepsilon_{max.}$ = 17,000) indicated the presence of the cinnamic acid double-bond system. The compound is therefore presumably ethyl α-bromomethylcinnamate. Conversion of the bromo-ester into cyano-ester by means of cuprous cyanide did not proceed smoothly; at 100°, the bromo-ester was largely unchanged; at 200°, a tarry product was obtained from which, after hydrolysis and hydrogenation, benzylsuccinic acid was isolated in poor yield, demonstrating that the bromine atom in the bromo-ester is attached to the α-methyl group. [Ziegler *et al.* (*Annalen*, 1942, **551**, 80) obtained cinnamyl bromide by reaction of 1-phenylpropene with *N*-bromosuccinimide.]

Experimental.—Ethyl α-methylcinnamate (33 g.) (Edeleanu, *Ber.*, 1887, **20**, 617) in carbon tetrachloride (70 c.c.) was boiled under reflux with *N*-bromosuccinimide (33 g.) for 24 hours. After cooling to 20°, succinimide (19 g.) was collected and the filtrate fractionated under reduced pressure to give *ethyl α-bromomethylcinnamate* (44 g., 94%), m. p. 40—42°, b. p. 110—112°/0·03 mm. After crystallisation from ethanol, the substance had m. p. 42° (Found : C, 53·8; H, 4·85; Br, 29·45. $C_{12}H_{13}O_2Br$ requires C, 53·55; H, 4·85; Br, 29·7%).

The bromomethyl compound (18 g.) was heated with cuprous cyanide (6·2 g.) at 200° until the vigorous reaction had subsided and kept at 200° for a further 15 minutes. The resulting tar was thoroughly extracted with small amounts of hot ethanol, the united extract was clarified with carbon and poured into cold water (500 c.c.), and the resulting oil extracted with ether (120 c.c.). The ethereal solution was dried and the ether removed. After distillation under reduced pressure (2 mm.), the distillate (5·6 g.) was boiled under reflux with aqueous 2N-sodium hydroxide (100 c.c.) for 16 hours, the solution acidified and cooled, and the product collected and recrystallised from hot water. The product (1·1 g.) was dissolved in water (25 c.c.), and sodium carbonate added until the solution was faintly alkaline to litmus. After hydrogenation at room temperature and pressure in the presence of Raney nickel catalyst, the solution was filtered and acidified, giving benzylsuccinic acid, m. p. 159° (from hot water) (Fittig and Shields, *Annalen*, 1895, **288**, 207, give m. p. 160°) (Found : C, 63·5; H, 5·85. Calc. for $C_{11}H_{12}O_4$: C, 63·45; H, 5·75%).—RESEARCH LABORATORIES, IMPERIAL CHEMICAL INDUSTRIES LIMITED, BLACKLEY, MANCHESTER, 9. [*Received, July 10th*, 1950.]

A New Synthesis of Indigo. By J. HARLEY-MASON.

THIELE (*Ber.*, 1899, **32**, 1293) obtained 2-nitro-1-*o*-nitrophenylethyl alcohol (I) by condensation of *o*-nitrobenzaldehyde with nitromethane, and observed that on treatment with ferrous sulphate and alkali it gave a blue pigment, which he guessed might be indigo. We have found that (I) can be converted into indigo in high yield by treatment with alkaline sodium dithionite (hydrosulphite), or in lower yield, by other alkaline reducing agents including ammonium sulphide, zinc dust and ammonium chloride, and ferrous sulphate and sodium hydroxide.

2-Nitro-1-(4 : 5-methylenedioxy-2-nitrophenyl)ethyl alcohol (II), obtained (as sodium salt) by the condensation of 6-nitropiperonaldehyde with nitromethane in the presence of sodium methoxide, gave 5 : 6 : 5′ : 6′-bismethylenedioxyindigo on similar treatment with dithionite. The dehydration products of (I) and (II), β : 2-dinitrostyrene and β : 2-dinitro-4 : 5-methylenedioxystyrene respectively, did not thus give indigos.

Experimental.—*o*-Nitrobenzaldehyde (5 g.) and nitromethane (2·3 g.) in methanol (15 ml.) were treated slowly at 0° with a solution of sodium methoxide [from sodium (0·9 g.) and methanol (10 ml.)]. After 12 hours at 0° the yellow crystalline sodium salt of 2-nitro-1-*o*-nitrophenylethyl alcohol was collected and washed with ether. This salt (3 g.) was dissolved in water (50 ml.), 2N-sodium hydroxide (15 ml.) was added, and sodium dithionite (6·5 g.) was then added slowly with stirring. A thick precipitate of indigo was formed at once. Air was drawn through the solution for 15 minutes to oxidise any leuco-compound, and the indigo (1·51 g., 90%) collected and purified by vacuum-sublimation (Found : C, 73·0; H, 4·1; N, 10·8. Calc. for $C_{16}H_{10}O_2N_2$: C, 73·3; H, 3·8; N, 10·7%).

Similar dithionite reduction of the product from 6-nitropiperonal (4 g.) and nitromethane (1·2 g.) gave 5 : 6 : 5′ : 6′-bismethylenedioxyindigo (1·5 g., 80%) (Found : C, 61·1; H, 3·0; N, 7·9. Calc. for $C_{18}H_{10}O_6N_2$: C, 61·9; H, 2·85; N, 8·0%).—UNIVERSITY CHEMICAL LABORATORY, CAMBRIDGE. [*Received, July 18th*, 1950.]

Solvolysis by Bromine Trifluoride. By A. G. SHARPE.

BROMINE TRIFLUORIDE has recently been shown to be a useful reagent for the preparation of complex fluorides in a non-aqueous medium (Woolf and Emeléus, *J.*, 1949, 2865; 1950, 1050; Emeléus and Woolf, *J.*, 1950, 164; Woolf, *J.*, 1950, 1053; Emeléus and Gutmann, *J.*, 1949, 2979; 1950, 1046; Sharpe, *J.*, 1949, 2901). With its aid a number of salts unstable to water have been prepared. In the conversion of a mixture of gold and silver into silver fluoroaurate, for example, the metals are first converted into the compounds $AuBrF_6$ and $AgBrF_4$, which are respectively an acid and a base on the bromine trifluoride system; these substances then react according to the equation :

$$[BrF_2][AuF_4] + Ag[BrF_4] = Ag[AuF_4] + 2BrF_3$$

Salts prepared by such methods, however, are often impure and contain bromine; analyses of typical products indicate compositions such as $K_2SnF_6,1{\cdot}15BrF_3$ and $NaAuF_4,0{\cdot}1BrF_3$. The simplest explanation of this retention of the elements of bromine trifluoride, firmly combined with the salts, is solvolysis, or incomplete reaction between acid and base. Evidence for the correctness of this explanation is presented below.

Titanium tetrafluoride forms with bromine trifluoride a compound which is unstable *in vacuo* at room temperature; in solution, this reacts as $(BrF_2)_2TiF_6$, and from it nitrosyl fluorotitanate, $(NO)_2TiF_6$, may be prepared. Attempts to make metal fluorotitanates, however, lead to the formation of products heavily contaminated with bromine (Woolf, *loc. cit.*). The reversibility of the reaction

$$2KBrF_4 + (BrF_2)_2TiF_6 \rightleftharpoons K_2TiF_6 + 4BrF_3$$

has now been demonstrated by showing that (*a*) combination of acid and base is incomplete, and (*b*) bromine trifluoride effects partial decomposition of pure potassium fluorotitanate. When a mixture

of equivalent proportions of potassium bromide and titanium dioxide was treated with bromine trifluoride, and the solvent removed by evaporation *in vacuo* at room temperature, the product corresponded in composition to K_2TiF_6,0·95BrF_3, and *X*-ray powder-photographic examination revealed the presence of potassium tetrafluorobromite (bromotetrafluoride), $KBrF_4$. Pure potassium fluorotitanate, prepared from iron-free titanium dioxide, potassium fluoride, and hydrofluoric acid, dissolved readily in bromine trifluoride; removal of the solvent yielded a product, K_2TiF_6,1·1BrF_3, again shown by powder photography to have $KBrF_4$ as a principal constituent. The heavy solvolysis of the fluorotitanates, the alternative method for their preparation, the instability of the TiF_4–BrF_3 addition product, and the lower scattering power of K_2TiF_6 and TiF_4 (formed by decomposition of the TiF_4–BrF_3 compound) combine to make this instance unusually favourable for the *X*-ray powder-photographic demonstration of the presence of $KBrF_4$ in the reaction products. There is, however, no reason to doubt that the impurity of other complex salts prepared by means of bromine trifluoride has a similar origin.

Experimental.—Treatment of equivalent amounts of potassium bromide and titanium dioxide with *ca.* 3 ml. of bromine trifluoride, followed by removal of the solvent in the usual way, gave a product (I) of composition K_2TiF_6,1·1BrF_3. This was decomposed quietly by dilute sodium hydroxide solution, titanium dioxide was filtered off, and bromine was determined in the filtrate as described by Sharpe and Emeléus (*J.*, 1948, 2135) (Found: Br, 20·2%; weight equiv. to TiO_2 = 80, 390. Calc. for K_2TiF_6,1·1BrF_3: Br, 22·5%; equiv., 391).

Potassium fluorotitanate, prepared by dissolving titanium dioxide and potassium fluoride in 40% hydrofluoric acid, was recrystallised from hydrofluoric acid in a platinum vessel; its fluorine content was determined by fusion with sodium carbonate, filtration of titanium dioxide, and precipitation as calcium fluoride (Found: F, 47·7. Calc. for K_2TiF_6: F, 47·6%).

A solution of concentration comparable to that obtained above yielded a product (II) of composition K_2TiF_6,0·95BrF_3 (Found: Br, 18·5%; equiv., 368. Calc. for K_2TiF_6,0·95BrF_3: Br, 20·5%; equiv., 370).

Samples of (I) and (II) were, without exposure to moist air, filled into Pyrex capillaries and sealed off well away from the fillings ($KBrF_4$ is thermally unstable). Photographs taken with Cu-$K\alpha$ radiation, using exposure times of 8—12 hours, showed clearly the seven strongest lines of the $KBrF_4$ powder pattern; these were the strongest lines on the photographs of (I) and (II), and the identification of $KBrF_4$ is thus beyond doubt.—UNIVERSITY CHEMICAL LABORATORY, CAMBRIDGE. [*Received, July 24th,* 1950.]

The Purification of Brucine. By H. KACSER.

BRUCINE has been extensively used for resolutions and latterly for kinetical studies of mutarotation phenomena. No reliable physico-chemical assessment of purity appears to be available. In addition to pharmaceutical specifications, there are meagre and conflicting data on the specific rotation (Oudemans, *Annalen*, 1873, **166**, 69; Hilditch, *J.*, 1908, **93**, 700; Tycociner, *Rec. Trav. chim.*, 1882, **1**, 145; Jamison and Turner, *J.*, 1942, 437).

Chloroform solutions of brucine were observed to develop a pale brown colour when kept in daylight and simultaneously their optical rotatory power decreased. The processes were faster under ultraviolet irradiation. It seems likely that the process is one of photochemical oxidation since small quantities of compounds resembling closely the neutral oxidation products obtained by Leuchs and his coworkers (Leuchs and Tessmar, *Ber.*, 1937, **70**, 2369; Leuchs and Boit, *Ber.*, 1940, **73**, 885) were isolated. These compounds, together with a substance with properties similar to ψ-brucine, could also be isolated in small quantities from samples of commercial brucine.

On account of this photo-oxidation, purification procedures such as that proposed by Saunders (*J. Amer. Chem. Soc.*, 1928, **50**, 123) which involve the liberation of moist brucine were not used in the final stages. Recrystallisation from solvents such as chloroform, carbon tetrachloride, ethanol, acetone, benzene, *p*-xylene, mesitylene, and acetophenone had disadvantages on account of retention of solvent (Kacser and Ubbelohde, *Nature*, 1949, **164**, 445) or because the solubility relationships were unfavourable. The best solvent was found to be toluene.

The course of separation was followed polarimetrically in each case. When toluene was used, the rotation of a sample of commercial brucine (B.D.H.) rose from $[\alpha]_{5461}^{20} = -139·6°$ to $-149·3°$ (in chloroform) after one extraction and two recrystallisations and did not alter significantly on further treatment with this or other solvents.

The final procedure adopted for purification was as follows: To 10 g. of brucine (B.P.) were added 200 c.c. of toluene (sulphur-free), and the mixture was shaken vigorously for 15 minutes. The solution was filtered and then concentrated to a third of its volume at *ca.* 50° under a vacuum. The crystals which formed on cooling and shaking were filtered off, washed with a little cold toluene, and dried in a vacuum-desiccator. Subsequent recrystallisations were carried out by dissolving the base in just sufficient toluene to effect solution at 50° and cooling to room temperature.

The following constants were taken as definitive: $[\alpha]_{5461}^{20} = -149·5°$, $[\alpha]_{5893}^{20} = -120·5°$ (*c*, 1 in pure dry chloroform). No appreciable temperature coefficient of rotation of solution was observed in the range 20—45°. A chloroform solution of purified brucine stored in blackened air-tight containers showed no significant change in rotation after 5 days.—QUEEN'S UNIVERSITY, BELFAST. [*Received, July 24th,* 1950.]
