NOTES.

182.   *Refrachor :   A New Physical Constant.*

By S. S. JOSHI and G. D. TULI.

A NEW physical constant for which we propose the name refrachor and the symbol $[F]$ has been obtained by associating parachor (P) with refractive index (n_D^{20}) according to the expression $[F] = - P \log (n_D^{20} - 1)$.   As a result of a study of a large number of compounds, we find that the observed refrachor of any compound is made up of two constants, one dependent on the atoms and the other on structural factors such as type of linkage, size of rings, etc.   Some of the atomic, group, and structural refrachors derived by us are given in the Table.   In deriving these, we have used throughout the parachor and refractive index values given by Vogel (*J.*, 1934, 333, 4758; 1938, 1323; 1940, 171, 1528; 1943, 636; 1946, 133; 1948, 607,

1804) and have adopted the procedure employed by him in the calculation of atomic and structural parachors.

Atomic, Structural, and Group Refrachors.

Atom, structure, or group.	Refrachor.	Atom, structure, or group.	Refrachor.
CH_2	12·89	I (aliphatic)	9·67
C (in CH_2)	−25·27	I (aromatic)	15·94
H (in CH_2)	19·08	Double bond (C:C)	28·70
O (in aliphatic ethers)	6·62	Triple bond (C⦂C)	60·18
OH (in aliphatic alcohols)	11·09	Three-carbon ring	22·55
CO (in ketones)	7·88	Four-carbon ,,	21·48
CO_2 (in esters)	17·64	Five-carbon ,,	17·15
CO_2H	25·6	Six-carbon ,,	13·05
Cl (aliphatic)	20·5	Me	31·83
Cl (aromatic)	25·53	Ph	41·94
Br (aliphatic)	16·51	NO_2 (nitro)	25·84
Br (aromatic)	22·80	NO_2 (nitrite)	35·64

As slight structural variations result in marked differences in refrachors, the constant may prove more useful than the parachor alone when applied to problems of chemical constitution. A few cases in which its utility has been studied so far are outlined below.

1. *Determination of the Percentage of Tautomers in their Equilibrium Mixture at 20°.*—For keto–enol tautomeric mixtures the difference between the calculated refrachors of the two forms is large (12·44 units), whereas it is quite small in the case of parachor (1·4 units) and molecular refractivity (1·08). Percentage composition calculated from refrachor determinations is quite comparable with values obtained from chemical methods (Conant and Thompson, *J. Amer. Chem. Soc.*, 1932, **54**, 4039; Meyer, *Ber.*, 1912, **45**, 2850).

Compound.	$[F]$, obs.	$[F]$, calc. Keto.	$[F]$, calc. Enol.	Enol, %, calc.	Enol, %, chemically found.
Ethyl acetoacetate	114·0	114·96	102·52	7·7	7·3 (Conant); 7·4 (Meyer)
Acetylacetone	83·30	92·31	79·87	72·4	76·5 (Conant); 76·0 (Meyer)
1 : 1-Diacetylethane	101·2	105·06	92·62	31·02	31·2 (Meyer)

2. *Distinction between Stably Linked and Reactive Halogen Atoms.*—Two sets of refrachor values are obtained for halogen atoms, according as they are reactive as in alkyl halides, etc., or are stably linked as in halogenated benzenes, etc. Comparison of observed and calculated refrachor values for, say, a halogenated homologue of benzene shows whether the halogen is in the nucleus or in the side chain. Similarly, in benzene derivatives in which halogen atoms are made reactive by other groups, *e.g.*, nitro, the refrachor values for the halogen atoms approach that of " aliphatic halogen " as the number of activating groups increases.

3. *Refrachor and Structural Variations.*—Isomeric groups and compounds in which the mode of linking of multivalent atoms is different show appreciable differences in their refrachors. Thus the refrachor values for the nitro and the nitrite group are 25·84 and 35·64, respectively, and for two double bonds and one triple bond are 57·4 and 60·18, respectively, whereas the parachor values for the same are 73·8, 75·3, 39·8, and 40·6, respectively. Refrachor can, therefore, prove of considerable help in the study of the structure of isomeric compounds.

Further work with this constant for determination of the type of linkage and elucidation of other structural problems is in progress.

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183. *The Freezing-point Diagram of the Hydrazine–Water System.*

By T. C. H. HILL and J. F. SUMNER.

THE cryoscopy of the hydrazine–water system has been studied by Semishin (*J. Gen. Chem., Russia*, 1938, **8**, 654). Mohr and Audrieth (*J. Phys. Coll. Chem.*, 1949, **53**, 901) have conducted a fuller investigation, yet have not covered the complete range owing to difficulties encountered at lower temperatures. We have covered the whole range, the results showing a maximum corresponding to the monohydrate and two eutectic points.

Experimental.—Hydrazine–water mixtures of an approximate pre-determined composition were prepared, and the f. p. determined in each case. An accurate determination of the hydrazine content was then made.

The apparatus (Fig. 1) consisted of a Pyrex tube (*A*) (4·5″ × 1″), fitted with a two-hole bung of polyvinyl chloride, which carried a calibrated alcohol thermometer (*B*) and a glass stirrer (*C*) supported in the cross-unit of a T-piece (*D*). The thermometer was calibrated by using it to determine in the apparatus the freezing point of pure water (0·0°), aniline (−6·4°), carbon tetrachloride (−22·95°), mercury (−38·86°), and chloroform (−63·3°). A correction curve was drawn and extrapolated slightly at both ends. For the four temperatures between −78° and −84°, comparison with an N.P.L.-standardised spirit thermometer was allowed to suffice. The third unit of *D* was connected to a supply of dry, oxygen-free nitrogen. An outer jacket (*F*) was provided, into which could be inserted the tube *A*, held in position by a split ring of polyvinyl chloride. By way of an inlet tube sealed in the bottom of *F*, a stream of dry air could be passed.

For a determination, 15 ml. of the hydrazine–water mixture were prepared in the tube *A*, and the thermometer and stirrer inserted. A slow stream of nitrogen was admitted, so as to preclude the introduction of atmospheric oxygen and moisture during stirring, and the liquid was carefully frozen by immersion in a cooling bath. For temperatures down to −70°, an acetone–solid carbon dioxide mixture was found to be satisfactory, and for lower temperatures an ethyl alcohol–liquid nitrogen mixture.

FIG. 1.

FIG. 2.

Hill and Sumner
Mohr and Audrieth
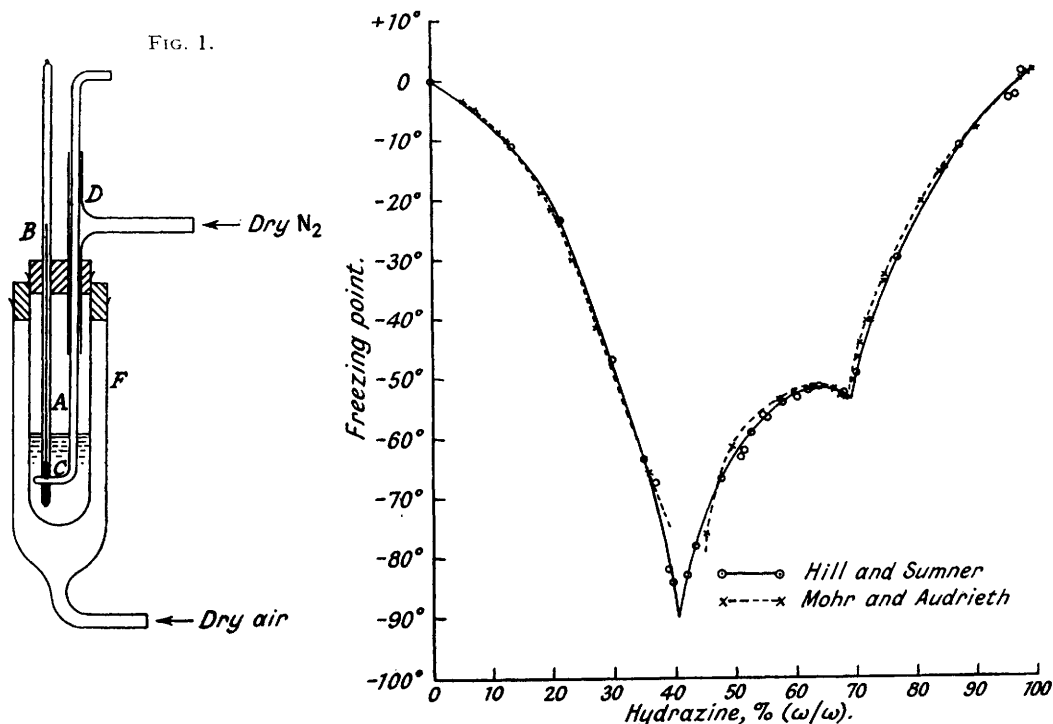
The freezing process being complete, the tube was transferred to the jacket *F*, and the temperature allowed to rise slowly. Condensation of moisture on the inner wall of *F*, and on the outer wall of *A*, was prevented by the passage of dry air. The freezing point of the solution was taken as the temperature at which the last trace of solid disappeared.

Some difficulty was at first experienced in ascertaining freezing points which occurred below −70° owing to the viscous nature of the system. However, this was satisfactorily surmounted after practice.

The contents of *A* were then allowed to attain room temperature, and a sample was withdrawn for analysis. The hydrazine content was determined iodometrically by Kolthoff's method (*J. Amer. Chem. Soc.*, 1924, **46**, 2009).

Results.—The values obtained are shown in the Table.

Freezing points of hydrazine–water mixtures.

N_2H_4, % (w/w) ...	0·0	13·3	21·4	29·8	34·9	36·8	38·9	39·6	42·1
F. p.	0·0°	−11·0°	−23·4°	−46·7°	−63·6°	−67·3°	−82°	−84°	−83°
N_2H_4, % (w/w) ...	43·3	47·7	50·9	51·6	52·9	54·7	55·4	57·9	60·5
F. p.	−78°	−66·7°	−63·1°	−61·8°	−58·9°	−56·0°	−56·5°	−54·1°	−53·2°
N_2H_4, % (w/w) ...	62·2	63·9	68·0	70·1	77·0	87·7	95·6	96·9	97·8
F. p.	−52·0°	−51·4°	−52·4°	−49·2°	−29·8°	−11·2°	− 3·4°	− 2·8°	+ 1·2°

Plotting the hydrazine concentration (% by wt.) against the f. p. of the solution (Fig. 2) shows a maximum at −51·5°, the concentration of hydrazine (64·0%) corresponding to the monohydrate,

N_2H_4,H_2O. Two eutectics are recorded, one at N_2H_4 40·5% (f. p. $-90°$), and the other at N_2H_4 69·3% (f. p. $-53·5°$).

The figures obtained by the authors correspond in general with those quoted by Mohr and Audrieth (*loc. cit.*) (cf. Fig. 2). The American investigators have not, however, effected a precise determination of the position of the water-rich eutectic. It is in this part of the diagram that the greatest difference occurs between the two sets of results.

The authors thank the Chief Scientist, Ministry of Supply, for permission to publish this paper, and Dr. K. A. Cooper for his interest and advice.

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184. *The Reaction between Diborane and Anhydrous Hydrazine.*

By H. J. EMELÉUS and F. G. A. STONE.

ANHYDROUS hydrazine has been found to react with excess of diborane at $0°$ to form hydrogen and a white hygroscopic solid which was involatile and insoluble in a variety of solvents. The reactants combined in unusually variable proportions in different experiments ($B_2H_6 : N_2H_4 = 1 : 0·78$—$0·97$), and the amount of hydrogen formed also varied. This suggests that the product may have been a mixture. The simplest and most probable initial reaction would be one in which the nitrogen atoms of hydrazine became co-ordinated to borine radicals, forming either $H_3B\cdot NH_2\cdot NH_2$ or $H_3B\cdot NH_2\cdot H_2N\cdot BH_3$, or both. Such products might well lose hydrogen and form more complex molecules in which boron atoms were linked by hydrogen bridges or co-ordinated with nitrogen in a second hydrazine molecule. This view is supported by the observation that when the initial product was hydrolysed and the hydrazine was estimated in the hydrolysate, the amount found corresponded closely to the total nitrogen content of the solid. Another indication that there was no cleavage of the N–N bond of hydrazine in this reaction is that no borazole was formed when the solid was heated to $180°$. Three samples examined lost approximately one molecular proportion of hydrogen, leaving an involatile residue of the empirical formula $BN_{1·12-1·26}H_{2·80-3·08}$. Although there is no evidence on which to assign a structure to such a compound, its mode of formation is clearly different from that of borazole from the compound $NH_4(BH_3\cdot NH_2\cdot BH_3)$. The initial product had strong reducing properties, decolorizing permanganate instantaneously and precipitating silver from silver nitrate solution. It also exploded when heated in air or on treatment with concentrated sulphuric acid.

Experimental.—Diborane was prepared by the reduction of boron trichloride with lithium aluminium hydride (Finholt, Bond, and Schlesinger, *J. Amer. Chem. Soc.*, 1947, **69**, 1199). Hydrazine of 99·2% purity, as determined by Andrews's method, was prepared by distilling samples of material, which may have contained a little water, from barium oxide immediately before use. In a typical experiment diborane (11·8 millimoles) was distilled on to hydrazine (7·4 millimoles) in a trap attached to a vacuum system. Reaction was allowed to proceed at $0°$ for 30 hours, after which diborane (5·6 millimoles) and hydrogen (3·58 millimoles) were recovered. There was no residual hydrazine or other product volatile *in vacuo*. The purity of the hydrogen was checked by explosion in a Hempel pipette. These data give a ratio of N_2H_4 and B_2H_6 reacting to hydrogen formed of $1 : 0·84 : 0·48$, corresponding to an empirical formula $BN_{1·2}H_{4·8}$ for the solid. The latter was also analysed (Found : B, 32·6, 30·4; H, 14·4; N, 52·0. Calc. for $BN_{1·2}H_{4·8}$: B, 33·4; H, 14·8; N, 51·8%). Data for a series of similar experiments are given below.

B_2H_6 taken (millimoles).	B_2H_6 recovered (millimoles).	N_2H_4 taken (millimoles).	H_2 formed (c.c.).	Ratio, $N_2H_4 : B_2H_6 : H_2$.
15·0	9·5	6·9	75	1 : 0·80 : 0·48
17·0	11·1	7·0	74	1 : 0·84 : 0·47
16·8	11·6	6·7	48·3	1 : 0·78 : 0·32
21·1	10·7	10·7	118	1 : 0·97 : 0·49
14·8	10·6	4·7	26·2	1 : 0·90 : 0·25

The product was insoluble in ether, benzene, acetone, chloroform, carbon tetrachloride, ethyl acetate, dimethylformamide, liquid ammonia, and hydrazine. With the last it reacted slowly, liberating hydrogen.

When samples of the solid product were heated in a vacuum in a sealed 100-c.c. bulb at 180—$200°$ for 2—3 hours, hydrogen was evolved and subsequently identified by being sparked with air. There

were no other volatile products. The residue was a white solid, the nitrogen and hydrogen content of which was determined. The following are the results of three such experiments:

Composition of solid.	$BN_{1\cdot19}H_{4\cdot82}$	$BN_{1\cdot26}H_{4\cdot92}$	$BN_{1\cdot12}H_{4\cdot94}$
Wt. taken (g.)	0·345	0·361	0·150
Vol. of H_2/g. of solid (c.c.)	242	262	99·1
Moles of H_2/mole of solid	1·01	1·08	0·93
Composition of the residue.	$BN_{1\cdot19}H_{2\cdot80}$	$BN_{1\cdot26}H_{2\cdot81}$	$BN_{1\cdot12}H_{3\cdot08}$
N; H, % (calc.)	55; 9·2	56·5; 9·0	53; 10·5
N; H, % (found)	52; 9·0	55; 9·0	51·5; 10·4

Samples of the initial reaction product were hydrolysed with 3N-hydrochloric acid at room temperature in an apparatus similar to that used by Eméleus and Woolf (*J.*, 1950, 164). Hydrogen evolution was at first rapid but subsequently became very slow. The volume of hydrogen per g. of solid in three experiments was 195, 120, and 140 c.c. This lack of consistency is probably due to the formation in the hydrolysis of lower acids of boron which decompose slowly with liberation of hydrogen.

A further indication that such acids are formed was given by the difficulty of estimating hydrazine in the hydrolysate by Andrews's method. Samples of the solid were boiled with dilute hydrochloric acid, but, on titration with potassium iodate, the titre was greater than expected and the end point was not permanent. When, however, the hydrolysed solution was set aside in air for 2—3 days before titration, a fairly permanent end point was obtained. The nitrogen content of the solid, estimated as hydrazine from these titrations, corresponded fairly closely with the nitrogen content of the solid used (Found, for a solid of the composition $BN_{1\cdot03}H_{4\cdot5}$: N, 48·1. Calc. for $BN_{1\cdot03}H_{4\cdot5}$: N, 48·5%. Found, for a solid of the composition $BN_{1\cdot33}H_{5\cdot1}$: N, 53·0. Calc. for $BN_{1\cdot33}H_{5\cdot1}$: 54·0%). The two formulæ given above as representing the composition of the solid used are based on the ratio of diborane and hydrazine reacting.

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185. *Chromatographic Separation of Choline-containing Phospholipids from Phospholipid Mixtures.*

By T. H. BEVAN, G. I. GREGORY, T. MALKIN, and A. G. POOLE.

ONE of the major difficulties in the phospholipid field is the separation of the naturally occurring complex mixtures into their four main types (lecithin, kephalin, sphingomyelin, phosphatidyl serine). In the light of recent work (cf. Hutt *et al.*, *Nature*, 1950, **165**, 314) earlier methods based on solubility relations are no longer valid, and methods based on complex salt formation are tedious and wasteful. For these reasons we have explored the possibility of chromatographic separation, and we find, using the technique outlined below, that it is possible to separate the phospholipids containing choline (lecithin and sphingomyelin) from those containing ethanolamine and serine (kephalin and phosphatidyl serine).

Experimental.—*Paper chromatograms.* Uniform spots of a 10% chloroform solution of the crude phospholipid mixtures were placed on the starting line of Whatman No. 1 filter-paper sheets which were then hung from troughs contained in glass tanks as described by Consden, Martin, and Gordon (*Biochem. J.*, 1944, **38**, 224).

The solvent used was a ternary mixture from the water-poor phase obtained from chloroform (800 ml.), ethyl alcohol (200 ml.), and water (25 ml.). The chromatograms were run for 6 hours at 18°; the solvent front had then almost reached the bottom of the papers ($\simeq 14''$ from the starting line), which were then removed and dried.

To detect the positions of the different phospholipids, the papers were divided longitudinally into two parts, which were treated as follows: (*a*) One was immersed in a 0·2% solution of ninhydrin in ethyl alcohol, removed, dried, and carefully heated before an electric fire. Blue or purple spots indicate the positions of the phospholipids containing ethanolamine and serine. (*b*) The other was treated with a 1% solution of phosphomolybdic acid in a mixture of equal volumes of ethyl alcohol and chloroform, washed in running water for 15—20 minutes, and dried. The position of the choline-containing phospholipids could be seen at this stage as faint yellow precipitates; on treatment with a 1% solution of stannous chloride in 3N-hydrochloric acid, well-defined blue spots appeared.

Lecithin obtained from ground nuts and egg yolk, by precipitation of the alcohol-soluble phospholipids with acetone, gave, respectively, three and four slow-moving fractions reacting with ninhydrin, but not with phosphomolybdic acid, of R_F values 0·02, 0·05, 0·20, and 0·02, 0·05, 0·17, and 0·28, together with a well-separated fraction reacting with phosphomolybdic acid, of R_F 0·90. Under the same conditions serine, choline, and ethanolamine gave R_F values of 0·01, 0·09, and 0·44 respectively.

Chromatograms of egg lecithin, purified by Pangbourne's improved cadmium chloride method

(*J. Biol. Chem.*, 1941, **137**, 545), which is regarded as the best method for the purification of lecithin, still showed the presence of ninhydrin-reactive material.

Saturated $\alpha\alpha'$- and $\alpha\beta$-phosphatidyl ethanolamines (kephalins) and $\alpha\beta$-dipalmityl phosphatidyl choline (lecithin), synthesised in this laboratory, have been chromatographed as above. The kephalins reacted with ninhydrin and had very low R_F values, whilst the lecithin reacted with phosphomolybdic acid and had R_F 0·97. This value was also found for a hydrogenated lecithin obtained from ground nuts.

A similar investigation carried out with a sphingolipid mixture obtained from beef brain by the method of Carter, Haines, Ledyard, and Norris (*J. Biol. Chem.*, 1947, **169**, 77) gave poorly separated ninhydrin-reactive fractions of low R_F values, and a well separated choline fraction of R_F 0·92.

Column separations (solvent as used for paper chromatograms). A column 40 cm. long and 4 cm. in diameter was packed with powdered cellulose as described by Hough, Jones, and Wadman (*J.*, 1949, 2511). The column was charged with a solution of 500 mg. of crude lecithin from ground nuts (as prepared above) in 5 ml. of solvent; this was washed on to the column with five successive 5-ml. portions of solvent. The solvent, supplied from a constant-head reservoir, was collected in 500-ml. portions. After removal of the solvent under reduced pressure, the solid residue was dissolved in 3—5 ml. of chloroform and poured into 10—15 ml. of acetone. The first two 500-ml. portions left no residue and were rejected; the third gave a copious precipitate ($\simeq$ 300 mg.), the fourth a small precipitate, and the fifth again left no residue.

Paper chromatograms of these materials showed complete absence of ninhydrin-reactive fractions. Chromatographic separation thus provides an efficient method of obtaining small samples of uncontaminated choline-containing phospholipids.

We thank Mr. D. A. Brown, who prepared our egg lecithin from commercial dried egg.

THE UNIVERSITY, BRISTOL.   [*Received, November 15th, 1950.*]

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186. *The Purification of Brucine.*

By E. E. TURNER.

IN a recent note (*J.*, 1950, 2908) Kacser states that "in addition to pharmaceutical specifications, there are meagre and conflicting data on the specific rotation" of brucine, and refers, among other papers, to one by Jamison and Turner (*J.*, 1942, 437). In fact, these authors do not give a value for the specific rotation of brucine in their paper. Kacser then says that "chloroform solutions of brucine were observed to develop a pale brown colour when kept in daylight. The processes were faster under ultra-violet radiation." He ascribed the change to photochemical oxidation of the brucine, referring to results obtained by Leuchs and others (*Ber.*, 1937, **70**, 2369; 1940, **73**, 885) under very different experimental conditions. In fact, as is well known, pure chloroform is oxidised under the influence of light, giving carbonyl chloride, and our records show that chloroform, originally pure, which has been kept for some time frequently gives a brownish or even a brownish-red colour with brucine, owing to the presence of carbonyl chloride. It is hardly necessary to say that under the influence of ultra-violet radiation pure chloroform is very rapidly oxidised to carbonyl chloride.

Kacser then says that his commercial sample of brucine had $[\alpha]_{5461}^{20}$ $-139\cdot6°$ in chloroform and that after being extracted by cold, and crystallised from warm, toluene its rotation rose to $-149\cdot3°$. In our experience, commercial brucine has a specific rotation up to about $[\alpha]_{5461}^{20}$ $-145°$ in chloroform, corresponding to a partly dehydrated tetrahydrate. The pure tetrahydrate has, according to our records, $[\alpha]_{5461}^{20}$ $-137\cdot7° \pm 0\cdot5°$ and $[\alpha]_{5780}^{20}$ $-117\cdot3° \pm 0\cdot5°$, in chloroform (c, $1\cdot000 \pm 0\cdot1$). This substance, or any hydrated brucine, would be dehydrated by Kacser's method of "purification," and azeotropic dehydration doubtless accounts for most, although possibly not for all, of his recorded rise in specific rotation. In our experience, if commercial hydrated brucine is once crystallised from water the resultant tetrahydrate is not very soluble in chloroform and a suspension of the air-dried material in this solvent appears to contain free water; addition of anhydrous sodium sulphate causes the brucine to dissolve and, if the solution is then poured into a large bulk of dry light petroleum (b. p. 40—60°), pure anhydrous brucine is precipitated having m. p. 178—179° (corr.), $[\alpha]_{5461}^{20}$ $-149\cdot9° \pm 0\cdot5°$, $[\alpha]_{5780}^{20}$ $-127\cdot6° \pm 0\cdot5°$ in pure chloroform (c of the order $1\cdot00$—$2\cdot50$).

Incidentally, if a dry solution of pure brucine in chloroform is treated with enough dry light petroleum to induce substantial crystallisation, the brucine crystallises with 1 mol. of chloroform as voluminous needles, having $[\alpha]_{5461}^{20}$ $-115\cdot8° \pm 0\cdot5°$ and $[\alpha]_{5780}^{20}$ $-98\cdot4° \pm 0\cdot5°$ in chloroform (c of order of $1\cdot00$). If this product is heated in a high vacuum at 120° to constant weight it gives pure anhydrous brucine, of m. p. 178—179° (corr.), $[\alpha]_{5461}^{20}$ $-149\cdot9° \pm 0\cdot5°$, $[\alpha]_{5780}^{20}$ $-127\cdot6° \pm 0\cdot5°$ in chloroform (c of order of $1\cdot00$).

Kacser, although claiming to have obtained " definitive " constants, does not give any indication of experimental error in his values for [α], nor does he say what kind of polarimeter tube he used. Our own observations were made with all-glass " macro " 2-dm. tubes, with a Lowry spectro-polarimeter, solutions being made up using routine precision methods (pure chloroform; thermostatically-controlled temperature; N.P.L.-standardised measuring flasks; etc.).

Kacser apparently interprets the results of Hilditch (*J.*, 1908, **93**, 700) as " conflicting." What Hilditch found was that the specific rotation varied with concentration, which is not unusual. In our experience the specific rotation of pure anhydrous brucine in pure chloroform does not change significantly over the concentration range 1—2·5. [The specific rotation of brucine tetrahydrate cannot be determined for $c = 2·5$ in chloroform, since the solubility of the hydrate is too low. Qualitative observation (cf. above) suggests that the hydrate is partly dehydrated by chloroform at room temperatures.]

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187.   1-*Nitromethylcyclohexanol.*

By GEORGE A. R. KON.

IN the course of some synthetic work now in progress in these laboratories a quantity of 1-nitromethyl*cyclo*hexanol was required. This substance had originally been obtained by Fraser and Kon (*J.*, 1934, 604) in the course of an investigation on nitromethyl*cyclo*hexene and related nitro-olefins.

In a recent communication Nightingale, Erickson, and Knight (*J. Org. Chem.*, 1950, **15**, 782) state that they were unable to repeat this preparation, but describe a successful method which differs but little from that originally published. Hass and Riley (*Chem. Reviews*, 1943, **32**, 384) also say that the earlier work could not be repeated and quote the results obtained by Bourland and by Larrison, whose work is recorded in theses (Purdue University, 1941 and 1942, respectively) and is not directly accessible to us. A similar statement is contained in a preamble to U.S.P. 2,343,256 (Hass and Bourland) and U.S.P. 2,383,603 (Larrison and Hass); however, this would appear to refer to the formation of dinitroalkanes from ketones and nitromethane and not to the condensation of *cyclo*hexanone with nitromethane.

When this condensation was repeated exactly in accordance with the original directions the nitro-alcohol was obtained without difficulty, although the yield did not exceed 27% and is thus comparable with that quoted by Nightingale, Erickson, and Knight (*loc. cit.*) (26% when the reaction mixture was not heated). An improved yield (43%) results from keeping the mixture for 3 days and a further improvement (to 47%) is attained by increasing the amount of sodium ethoxide three-fold. However, a further increase in the amount of catalyst does not appear to be desirable; an equimolecular amount of sodium ethoxide affords a fair yield of condensation product, but this consists largely of the olefin, nitromethyl*cyclo*hexene (Found : C, 58·0; H, 8·2. Calc. for $C_7H_{11}O_2N$: C, 59·5; H, 7·9%), which is also the main product when piperidine is used as a catalyst. With sodium *iso*propoxide the yields are somewhat lower than with the ethoxide and lower still (33%) with the methoxide.

Experimental.—The optimum conditions for the condensation appear to be the following : a solution of 0·5 g. of sodium in 15 c.c. of ethanol is added to a mixture of 12·2 g. of nitromethane and 19·6 g. of *cyclo*hexanone (0·2 mole of each) and the whole kept at room temperature for 3 days. Water and 2N-sulphuric acid are added, the oil extracted with ether, and the extract shaken with water, 2N-sodium hydrogen carbonate, and again with water. The solvent is removed from the dried (Na_2SO_4) solution and the residue distilled from a flask with a short Vigreux column. The yield of material, b. p. 125—127°/17 mm., is 12 g. (47%) (Found : N, 9·1. Calc. for $C_7H_{13}O_3N$: N, 8·8%).

In all the above experiments carefully purified materials were used; in particular, the nitromethane was shaken with 2N-sodium hydrogen carbonate, dried, and redistilled. When a commercial specimen of nitromethane was used without purification the yield of nitro-alcohol was halved and this may well be an important factor; on the other hand, there appears to be no advantage in warming the reaction mixture to 50° and using the stronger solution of catalyst recommended by Nightingale *et al.* (*loc. cit.*), or in the precautions used by them in preparing it (these do not, in any case, differ significantly from the standard textbook procedure). Nevertheless, it must be admitted that the original yield of 45% is not always attained and we are at present unable to account for this discrepancy.

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188. 7-*Ethyl-2-methylnaphthalene,* 7-*Ethyl*-1 : 2-*dimethylnaphthalene, and* 6-*Ethyl*-1 : 4-*dimethylnaphthalene.*

By WESLEY COCKER and DONAL H. HAYES.

IN the course of a wider investigation it became necessary, for comparative purposes, to synthesise the substituted naphthalenes mentioned in the title. 6-Ethyl-1 : 4-dimethyl-naphthalene has previously been obtained from santinic acid by heating it with barium oxide (Gucci and Grassi-Cristaldi, *Gazzetta*, 1892, **22**, I, 41) and by synthesis from 4-ethylacetophenone (Ruzicka and Eichenberger, *Helv. Chim. Acta*, 1930, **13**, 1117, 1123).

7-Ethyl-2-methyl- and 7-ethyl-1 : 2-dimethyl-naphthalene, which are new, were obtained as follows. Methylsuccinic anhydride was condensed with ethylbenzene to yield β-*p*-ethylbenzoyl-*iso*butyric acid (cf. Cocker *et al.*, *Chem. and Ind.*, 1949, 641, for earlier refs.; *J.*, 1950, 1781). Its identity was established by an unambiguous synthesis. ω-Chloro-4-ethylacetophenone (Auwers, *Ber.*, 1906, **39**, 3759) with ethyl methylmalonate gave an ester which, on hydrolysis and heating above its melting point, yielded β-*p*-ethylbenzoyl*iso*butyric acid. This was reduced to the corresponding butyric acid which was cyclised to 7-ethyl-1 : 2 : 3 : 4-tetrahydro-1-keto-2-methylnaphthalene. Reduction, followed by dehydrogenation, gave 7-ethyl-2-methyl-naphthalene, and reaction of the tetralone with methylmagnesium iodide gave a product which when dehydrogenated yielded 7-ethyl-1 : 2-dimethylnaphthalene.

6-Ethyl-1 : 4-dimethylnaphthalene was obtained by condensation of *p*-xylene with ethyl-succinic anhydride which gave β-(2 : 5-dimethylbenzoyl)-α-ethylpropionic acid as the main product. This was converted into the desired naphthalene by conventional methods.

7-*Ethyl-2-methylnaphthalene.*—β-p-*Ethylbenzoylisobutyric acid.* A solution of ethylbenzene (10 g.) and methylsuccinic anhydride (10 g.), in nitrobenzene (150 c.c.), was treated with aluminium chloride (25 g.), in nitrobenzene (50 c.c.), and the mixture was set aside overnight. After decomposition with ice and hydrochloric acid, the nitrobenzene layer was separated, washed with water, and extracted several times with ammonia. The extract was distilled in steam and acidified, yielding a solid (15 g.; m. p. 87—95°). It was crystallised thrice from dilute alcohol from which the required *keto*-acid (10 g.) was obtained as fine needles, m. p. 108—109° (Found : C, 71·0; H, 7·3. $C_{13}H_{16}O_3$ requires C, 70·9; H, 7·3%). Its *semicarbazone* crystallised from dilute alcohol as needles, m. p. 186° (Found : C, 60·3; H, 6·7. $C_{14}H_{19}O_3N_3$ requires C, 60·6; H, 6·9%).

α-*Carboxy-*β-p-*ethylbenzoylisobutyric acid.* ω-Chloro-4-ethylacetophenone (7·5 g.), in dry ether (50 c.c.), was slowly added to the sodio-derivative of ethyl methylmalonate [from this ester (7·2 g.) and sodium (0·95 g.)], in ether (100 c.c.). The mixture was stirred and refluxed for 4 hours. Water was added, and the ethereal layer separated, dried, and distilled. The fraction (1·6 g.), b. p. 210—212°/11 mm., consisted of the required ester. This was hydrolysed with excess of 10% methanolic potassium hydroxide and yielded the required *acid* (1·1 g.), m. p. 164—167° (decomp.), which separated from methyl alcohol as micro-needles, m. p. 167—168° (decomp.) (Found : *M*, 270. $C_{14}H_{16}O_5$ requires *M*, 264).

β-p-*Ethylbenzoylisobutyric acid.* The preceding compound (0·75 g.) was heated at 180° for 10 minutes and the product crystallised from dilute alcohol. It then gave m. p. 107°, undepressed by a sample prepared by the alternative method described above.

γ-p-*Ethylphenyl-α-methylbutyric acid*, obtained (4·7 g.) from the above keto-acid (10 g.), distilled at 193—194°/5 mm. (Found : C, 75·9; H, 8·6. $C_{13}H_{18}O_2$ requires C, 75·7; H, 8·7%). Its acid chloride, obtained by treatment of the acid (4·3 g.) with thionyl chloride (2·2 c.c.) overnight at room temperature, followed by refluxing for 30 minutes, distilled at 170—175°/20 mm.

7-*Ethyl*-1 : 2 : 3 : 4-*tetrahydro-1-keto-2-methylnaphthalene.* The acid chloride (3·5 g.) in carbon disulphide (100 c.c.) was treated with aluminium chloride (2·3 g.) added in one portion. The mixture was refluxed for 10 minutes, cooled, decomposed with ice and hydrochloric acid, and distilled in steam. The distillate yielded an oily *ketone* (3 g.), b. p. 166—167°/20 mm. (Found : C, 82·7; H, 8·25. $C_{13}H_{16}O$ requires C, 83·0; H, 8·5%). Its *semicarbazone* (colourless prisms) had m. p. 217—219·5° (Found : C, 68·5; H, 7·8. $C_{14}H_{19}ON_3$ requires C, 68·6; H, 7·8%).

7-*Ethyl*-1 : 2 : 3 : 4-*tetrahydro-2-methylnaphthalene* was obtained as an oil (0·8 g.; b. p. 128—132°/15 mm.) by the reduction of the above tetralone (1·5 g.) (Found : C, 88·5; H, 11·1. $C_{13}H_{18}$ requires C, 89·6; H, 10·4%).

7-*Ethyl-2-methylnaphthalene.* The tetralin (0·7 g.) was heated with selenium (2·1 g.) for 2·5 hours at 335—340°. The product (b. p. 125—128°/10 mm.) was distilled from sodium and converted into its picrate from which the pure *naphthalene* was regenerated, b. p. 135—140°/15—20 mm. (Found : C, 91·2; H, 8·4. $C_{13}H_{14}$ requires C, 91·8; H, 8·2%). Light absorption : Max., <2300, 2740 (2910), 3170, and 3200 A.; log ε = ?, 3·63 (2·37), 2·30, and 2·30, respectively. Its *picrate* crystallised from methyl alcohol as bright yellow needles, m. p. 85—85·5° (Found : C, 56·5; H, 4·3. $C_{19}H_{17}O_7N_3$ requires C, 57·1; H, 4·3%).

7-*Ethyl*-1 : 2-*dimethylnaphthalene.*—7-*Ethyl-3* : 4-*dihydro*-1 : 2-*dimethylnaphthalene.* The above tetra-lone (2·5 g.) in dry ether (30 c.c.) was slowly added to a stirred, boiling solution of methylmagnesium

iodide (from magnesium, 1 g.). The mixture was refluxed for 1 hour, cooled, and decomposed with ice and sulphuric acid. The ethereal layer yielded an oil (3 g.; b. p. 140—147°/17 mm.), which was heated for 1 hour at 160° with potassium hydrogen sulphate (7·6 g.). The oily *dihydro*-compound (2·2 g.) distilled at 149—154°/18 mm. It did not give a satisfactory analysis (Found : C, 87·0; H, 8·9. $C_{14}H_{18}$ requires C, 90·3; H, 9·7%).

7-Ethyl-1 : 2-dimethylnaphthalene. The previous compound (2 g.) was heated with selenium (6 g.) at 335—340° for 2·5 hours and yielded a *hydrocarbon* (1·1 g.), which was purified through its picrate and then distilled at 133—135°/10 mm. (Found : C, 91·2; H, 8·8. $C_{14}H_{16}$ requires C, 91·3; H, 8·7%). Light absorption : Max., <2300(2700), 2810, and 3190 A.; log ε = ? (3·61), 3·69, and 2·43 respectively. Its *picrate* crystallised from methyl alcohol as orange needles, m. p. 104—105° (Found : C, 58·1; H, 4·7. $C_{20}H_{19}O_7N_3$ requires C, 58·1; H, 4·6%). Its *trinitrotoluene* adduct crystallised from methyl alcohol as lemon-yellow needles, m. p. 88—89° (Found : C, 61·3; H, 5·2. $C_{21}H_{21}O_6N_3$ requires C, 61·3; H, 5·1%).

6-Ethyl-1 : 4-dimethylnaphthalene.—β-(2 : 5-*Dimethylbenzoyl*)-α-*ethylpropionic acid.* Ethylsuccinic anhydride (11 g.) was condensed, at room temperature, with *p*-xylene (11 g.), in nitrobenzene (100 c.c.) using aluminium chloride (26 g.) in nitrobenzene (75 c.c.). The *product* (13 g.) was a yellow solid, m. p. 81—85°, which separated from dilute alcohol as flat prisms, m. p. 100—102° (Found : C, 71·5; H, 7·5. $C_{14}H_{18}O_3$ requires C, 71·8; H, 7·7%). Its *semicarbazone* separated from alcohol as prisms, m. p. 164—165° (Found : C, 62·6; H, 7·4. $C_{15}H_{21}O_3N_3$ requires C, 61·9; H, 7·2%).

γ-(2 : 5-*Dimethylphenyl*)-α-*ethylbutyric acid* (7·6 g.) was obtained from the previous compound (8·4 g.) as a colourless oil, b. p. 195—197°/15 mm. (Found : C, 76·1; H, 9·2. $C_{14}H_{20}O_2$ requires C, 76·4; H, 9·1%). Its acid chloride distilled at 163—166°/10 mm.

2-Ethyl-1 : 2 : 3 : 4-tetrahydro-1-keto-5 : 8-dimethylnaphthalene (3·5 g.) was obtained from the acid chloride (4·1 g.) in carbon disulphide (250 c.c.), by cyclisation with aluminium chloride (2·7 g.). The reaction was completed by heating for 10 minutes and the *tetralone* was collected at 267—270°/16 mm. (Found : C, 82·7; H, 8·8. $C_{14}H_{18}O$ requires C, 83·2; H, 8·9%). It failed to yield a semicarbazone.

2-Ethyl-1 : 2 : 3 : 4-tetrahydro-5 : 8-dimethylnaphthalene (2·4 g.) was obtained from the tetralone (2·7 g.). It was collected at 146—147°/10 mm. (Found : C, 89·0; H, 10·7. $C_{14}H_{20}$ requires C, 89·4; H, 10·6%).

6-Ethyl-1 : 4-dimethylnaphthalene. The tetrahydro-compound (1·7 g.), heated with selenium (5·1 g.) for 2·5 hours at 335—340°, gave an oil (1·5 g.) which, when purified through its picrate, distilled at 158—161°/21 mm. Light absorption : Max., <2300, 2880, and 3250 A.; log ε = ?, 3·54, and 2·49 respectively. The m. p. of the picrate (red needles from methanol) remained steady at 80° (cf. Ruzicka and Eichenberger, *loc. cit.*, who give m. p. 85°). Its trinitrobenzene and trinitrotoluene adducts dissociated on attempted crystallisation.

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189. *The Preparation of* 17α-*Propargyltestosterone.*

By D. MAGRATH, V. PETROW, and R. ROYER.

DEHYDROEPIANDROSTERONE failed to react with propargyl bromide under the usual conditions of the Reformatsky reaction, and the addition of mercuric chloride or copper bronze to the reaction mixture proved of no avail. On replacement of propargyl bromide by the iodide, however, reaction occurred to give 3β-acetoxy-17α-propargylandrost-5-en-17β-ol (I) in 21% yield. Hydrolysis gave the corresponding 3β-hydroxy-compound, oxidised by the Oppenauer method to 17α-propargyltestosterone (II).
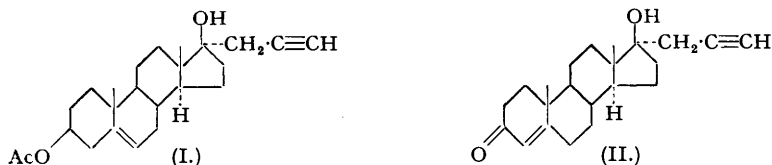
Dr. S. W. F. Underhill and Mr. W. S. Parr (Physiological Department, The British Drug Houses, Ltd.) have kindly examined (I) and (II) for biological activity with the following results :

	(I.)	(II.)
Androgenic activity	0	0
Œstrogenic activity, i.u./mg.	1·0	0
Progestational activity, i.u./mg.	0·002	0·004

The low biological activity of (II) is somewhat surprising as 17α-ethynyltestosterone—of which (II) is the homo-derivative—has about one-third of the activity of progesterone on subcutaneous

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injection (cf. Inhoffen, Logemann, Hohlweg, and Serini, *Ber.*, 1938, **71**, 1024), whilst 17α-ethyltestosterone has about one-fifth of the androgenic activity of testosterone (Ruzicka, Goldberg, and Rosenberg, *Helv. Chim. Acta*, 1935, **18**, 1487).

Experimental.—Microanalyses are by Drs. Weiler and Strauss, Oxford. M. p.s are uncorrected. Optical rotations were measured in chloroform solution in a 2-dm. tube.

3β-Acetoxy-17α-propargylandrost-5-en-17β-ol (I). A solution of dehydro*epi*androsterone acetate (20 g.) in a mixture of dry benzene (40 ml.) and propargyl iodide (20·1 g.) was added slowly under anhydrous conditions to a stirred mixture of activated zinc dust (40 g. of sludge in benzene) in benzene (40 ml.), maintained under reflux. Reaction was completed by heating the whole for a further 30 minutes, whereafter the mixture was cooled, decomposed with ice-cold 2N-hydrochloric acid (400 ml.), and extracted with ether. The product (21·4 g.) in benzene solution was filtered through alumina (50 g.; B.D.H.), evaporation of the combined benzene eluates followed by crystallisation from methanol and finally acetone yielding *3β-acetoxy-17α-propargylandrost-5-en-17β-ol* as needles, m. p. 149° (Found : C, 77·8; H, 9·3. $C_{24}H_{34}O_3$ requires C, 77·8; H, 9·3%).

17α-Propargylandrost-5-en-3β : 17β-diol, obtained by hydrolysis of the foregoing compound with alcoholic potash, formed needles (from benzene), m. p. 153—155°, $[\alpha]_D^{23}$ −91·0° (*c*, 0·382) (Found : C, 80·6; H, 10·0. $C_{22}H_{32}O_2$ requires C, 80·4; H, 9·8%).

17α-Propargyltestosterone (II).—A mixture of the foregoing compound (1·8 g.), aluminium *iso*propoxide (7·2 ml. of a 25% solution in toluene), toluene (33 ml.), and *cyclo*hexanone (19·2 ml.), was heated under reflux for 1½ hours. The cooled mixture was added to ice and 5N-hydrochloric acid (75 ml.), and the product extracted with ether. Treatment with light petroleum (200 ml.; b. p. 40—60°), followed by storage at 0°, gave a solid product (1·24 g.) which was repeatedly crystallised from aqueous methanol. *17α-Propargyltestosterone* formed flakes (48%), m. p. 136—137°, $[\alpha]_D^{26}$ +57·3° (*c*, 0·417) (Found : C, 81·2; H, 9·4. $C_{22}H_{30}O_2$ requires C, 80·9; H, 9·3%).

The authors thank the Directors of The British Drug Houses for permission to publish these results.

CHEMICAL RESEARCH LABORATORIES, THE BRITISH DRUG HOUSES, LTD.,
LONDON, N.1.   [*Received, December 22nd*, 1950.]

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190. *The Reduction of Aromatic Hydrocarbons with Lithium Aluminium Hydride.*

By ISAAC GOODMAN.

THE sole claim to the reduction of the aromatic nucleus by means of lithium aluminium hydride appears to be that by Sampey and Cox (*J. Amer. Chem. Soc.*, 1949, **71**, 1507) to have prepared tetrahydroanthracene and dihydrophenanthrene from anthracene and phenanthrene, respectively, at elevated temperatures (cf. Johnson, *Ann. Reports*, 1949, **46**, 143, where, however, a clerical error occurs).

The American authors, however, state that their tetrahydroanthracene was identified by a mixed melting point with " a sample prepared by reduction of anthracene with Raney nickel (m. p. 103—104°)," whilst " the dihydrophenanthrene and its picrate were identical with those prepared by Schmidt (*Ber.*, 1907, **40**, 4240)." These identifications are, however, known from other work to be unsatisfactory (cf. Schmidt *et al.*, *Ber.*, 1908, **41**, 4225; Schroeter, Müller, and Huang, *Ber.*, 1929, **62**, 645; Burger and Mosettig, *J. Amer. Chem. Soc.*, 1935, **57**, 2731; Durland and Adkins, *ibid.*, 1937, **59**, 138; Hall, Lesslie, and Turner, *J.*, 1950, 711; Garlock and Mosettig, *J. Amer. Chem. Soc.*, 1945, **67**, 2255; Kagehira, *Bull. Chem. Soc. Japan*, 1931, **6**, 241; Waterman, Leendertse, and Cranendonk, *Rec. Trav. chim.*, 1939, **58**, 83). In extensive work in this Laboratory, Raney nickel has never led to tetrahydroanthracene. Whilst the melting point given by Sampey and Cox is correct for tetrahydroanthracene, it is also close to that of 9 : 10-dihydroanthracene.

The reaction of anthracene and phenanthrene with lithium aluminium hydride has therefore been re-examined. The product from anthracene was obtained in substantially the yield and with the properties recorded by Sampey and Cox. Comparison with authentic samples showed it to be 9 : 10-dihydroanthracene and its characterisation was completed by oxidation to anthraquinone in conditions found by Schroeter (*Ber.*, 1924, **57**, 2003) to yield tetrahydroanthraquinone from tetrahydroanthracene, and anthraquinone from the dihydro-compound. The product from the reaction with phenanthrene was almost entirely unchanged hydrocarbon.

It is interesting that Sampey and Cox (*loc. cit.*) noted that neither naphthalene nor anthracene was reduced by the reagent in dioxan or ether. Indeed, the reaction with anthracene occurs only at a temperature above that at which lithium aluminium hydride decomposes and at

which phenanthrene was not attacked. There is therefore no evidence that a truly aromatic (benzenoid) nucleus has ever been reduced by this reagent. The reaction in the case of anthracene is associated with its meso-reactivity, and leads to a stable product with two benzenoid rings.

Experimental.—The conditions employed were substantially identical with those used by Sampey and Cox (*loc. cit.*). The pure hydrocarbons (9 g.) and the powdered reagent (8 g.) were heated at 220—230° for 6 hours in a nitrogen atmosphere, with continuous stirring by a steel paddle stirrer. In each case, a very vigorous reaction set in at about 210°, but shortly subsided. This was found to occur with the reagent alone, and corresponds to the exothermic decomposition of the latter. The cooled reaction mixtures were decomposed cautiously by water. The hydrocarbon products were isolated by repeated extraction with toluene (anthracene experiment) and with ethanol (phenanthrene experiment). The inorganic residues were then treated with acid to liberate remaining traces of hydrocarbon, which in the case of anthracene were accompanied by a small amount of carbonaceous material. The various hydrocarbon extracts were then combined and examined as follows.

Phenanthrene. Fractional crystallisation yielded three crops (7·14 g., in all), identified in each case as phenanthrene. The remaining alcoholic solution gave an orange-coloured picrate (0·8 g.), m. p. 142—144°, consisting of slightly impure phenanthrene picrate (equiv. to 0·35 g. of hydrocarbon). The total recovery of phenanthrene was thus 7·49 g. (83%). The mother-liquor from the picrate was treated with alkali and yielded a small hydrocarbon residue (0·17 g.) which was mainly oily, with a trace of crystalline component. The refractive index of the oil (n_D^{20} 1·6115) is lower than that recorded for dihydrophenanthrene (Burger and Mosettig, *loc. cit.*; Durland and Adkins, *J. Amer. Chem. Soc.*, 1938, **60**, 1501) so that formation of this hydrocarbon does not occur. Phenanthrene comprised 97·7% of the total recovered hydrocarbon.

Anthracene. Partial evaporation of the toluene solution gave two crops of crystals (total wt., 3·63 g.) identified as anthracene; the second crop was accompanied by traces of some orange-yellow crystals which were mechanically separated and had m. p. 254—258°. (This material did not yield a picrate in alcohol solution, and was not decolorised by maleic anhydride in xylene; it has not been further examined). The remaining toluene solution was evaporated to dryness, yielding a buff-coloured solid (4·63 g.) of m. p. 88—100°. The total hydrocarbon recovery was therefore 8·26 g. (91·8%), of which 43·9% was anthracene. Sampey and Cox claimed a 60% yield of tetrahydroanthracene in these conditions.

Crystallisation of the lower-melting reaction product from ethanol gave two fractions (2·7 and 0·75 g., respectively). Fraction A occurred as pale slightly yellow needles, m. p. 104—106°, not affected by recrystallisation. Fraction B had m. p. 103—105°. The crystal form of these materials differed from that of tetrahydroanthracene, and both depressed the m. p. on admixture with a synthetic specimen of the tetrahydro-compound. Both fractions resembled 9 : 10-dihydroanthracene, however, and did not depress the m. p. of an authentic sample (m. p. 107°) obtained by copper chromite-catalysed hydrogenation of anthracene (Burger and Mosettig, *loc. cit.*).

Fraction A (or B) (0·5 g. each) in acetic acid (4 c.c.) was treated with chromium trioxide (1·25 g.) in acetic acid (4 c.c.) and water (1 c.c.) with cooling. After 15 hours, the crystalline products were filtered off and washed with alcohol. Fraction A gave anthraquinone (0·5 g.), m. p. 278°, as sole product; fraction B gave the same quinone (0·48 g.), m. p. 266—270°, and dilution of the mother-liquors gave a further 0·09 g. of quinone, m. p. 160—220°. It thus appeared that fraction B might contain a trace of material other than 9 : 10-dihydroanthracene. This is not tetrahydroanthracene, however, for neither fraction B nor its yellow alcoholic mother-liquors gave derivatives with either picric acid or trinitrobenzene.

The author is indebted to Dr. E. T. Borrows for a discussion.

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    Twining Road, Manchester, 17.   [*Received, November 24th*, 1950.]

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191. *Pregna-4 : 16 : 20-trien-3-one.*

By J. K. Norymberski.

During preparation of 3-ketopregna-4 : 17-dien-21-yl acetate (I; R = OAc) by allylic rearrangement of 17α-vinyltestosterone with phosphorus tribromide and subsequent treatment of the crude bromide (I; R = Br) with potassium acetate in boiling acetone (Ruzicka and Müller, *Helv. Chim. Acta*, 1939, **22**, 416), formation of a by-product, m. p. 140—141°, was repeatedly observed. The same compound was formed from pure 3-ketopregna-4 : 17-dien-21-yl bromide (I; R = Br) under identical conditions; however, if the reaction was carried out at room temperature the by-product was not formed. The by-product analysed as $C_{21}H_{28}O$ and exhibited an absorption maximum at 238 mμ. (ε = 31,500), obviously to be explained by superposition of the band of a 4 : 5-unsaturated 3-ketone on that of a system of

conjugated double bonds. The presence of conjugated double bonds was supported by formation of a maleic anhydride adduct. These results strongly suggest that the compound is pregna-4 : 16 : 20-trien-3-one (II).

Reich (*Helv. Chim. Acta*, 1940, **23**, 219) reported the isolation of a compound, m. p. 124—135°, from the pyrolysis of 3-ketopregna-4 : 17-dien-21-yl pyridinium bromide (I; R = Br{NC$_5$H$_5$}) and, without further characterisation, proposed for it, formula (II). This work was repeated and the product of pyrolysis found to be identical with the " trienone " obtained from 3-ketopregna-4 : 17-dien-21-yl bromide (I; R = Br) and potassium acetate.

Experimental.—Microanalyses by Drs. Weiler and Strauss, Oxford.

Treatment of 3-ketopregna-4 : 17-dien-21-yl bromide with potassium acetate. (*a*) Crude 3-ketopregna-4 : 17-dien-17-yl bromide, prepared from 17α-vinyltestosterone (1·2 g.) by Ruzicka and Müller's procedure (*loc. cit.*), was heated in acetone (20 c.c.) with anhydrous potassium acetate (3·0 g.) and potassium iodide (trace) under reflux for 2 hours. After cooling, the mixture was diluted with ether (20 c.c.), the potassium salts were removed by filtration, and the filtrate was freed from solvents. The residue (1·3 g.) gave, on crystallisation from hexane, 3-ketopregna-4 : 17-dien-21-yl acetate (0·70 g.), m. p. 85—93°; recrystallisation from aqueous methanol raised the m. p. to 105—106°. Chromatography of the mother-liquors on neutral alumina gave a further quantity (0·29 g.) of the same product (fractions 5—7, benzene–light petroleum, 1 : 1, and benzene). Fractions 3 and 4 (0·16 g.) eluted with benzene–light petroleum (1 : 1) gave, on crystallisation from methanol, pregna-4 : 16 : 20-trien-3-one in long needles, m. p. 140—141°, undepressed on admixture with the trienone, m. p. 137—140°, prepared by Reich's procedure (*loc. cit.*), [α]$_D$ +147° (*c*, 0·754, in chloroform). Light absorption (in ethanol): Max. 238 mμ.; ε = 31,500 (Found: C, 84·9; H, 9·6. Calc. for C$_{21}$H$_{28}$O: C, 85·1; H, 9·5%).

(*b*) The pure bromide (2·0 g.; m. p. 126—127°) was treated as under (*a*) with potassium acetate (3·0 g.) and potassium iodide (trace) in boiling acetone (70 c.c.). The crude reaction product gave, on repeated crystallisation from aqueous methanol, needles (0·27 g.), m. p. 137—140°, identical with the " trienone " from (*a*). The normal product, 3-ketopregna-4 : 17-dien-21-yl acetate (0·90 g.), was obtained from the mother-liquors.

(*c*) The pure bromide (2·0 g.) was shaken with anhydrous potassium acetate (3·0 g.) and potassium iodide (trace) in acetone (70 c.c.) for 20 hours at 18°. Crystallisation of the crude reaction product from hexane and then from aqueous methanol gave the acetate (0·77 g.), m. p. 102—104°. Chromatography of the mother-liquors on neutral alumina gave only further quantities of the same product.

Maleic anhydride adduct. The foregoing " trienone " (0·225 g.) was heated in dry, thiophen-free benzene (2 c.c.) with maleic anhydride (0·075 g.) for 4 hours under reflux. After 3 days at 17—20° the *adduct* (0·15 g.) was collected; it crystallised from ethyl acetate in colourless needles, m. p. 241—243° (*in vacuo*) (Found : C, 75·8; H, 7·5. C$_{25}$H$_{30}$O$_4$ requires C, 76·1; H, 7·6%).