2-o-*Hydroxymethylphenyl-2-phenylpropan*-1-*ol and its Reaction with Hydrogen Bromide.*

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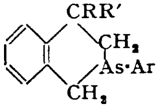
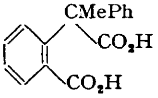
Reduction of α-methyl-α-phenylhomophthalic anhydride with lithium aluminium hydride has given 2-*o*-hydroxymethylphenyl-2-phenylpropan-1-ol. Subsequent reaction with hydrogen bromide resulted in a *neo*pentyl rearrangement accompanied by ring closure on to an aliphatic carbon atom to yield 3-methyl-2-phenylindene.

As part of a programme aiming at the demonstration of asymmetry arising from a tervalent arsenic atom, we attempted the synthesis of an unsymmetrically 4 : 4-substituted 2-aryl-1 : 2 : 3 : 4-tetrahydro*iso*arsinoline (I). We have been unsuccessful in this, but our experiments have shown an interesting rearrangement and ring closure.



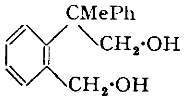
(I)



(II)

We previously showed that ethyl homophthalate is reduced by lithium aluminium hydride to *o*-2-hydroxyethylbenzyl alcohol (Anderson and Holliman, *J.*, 1950, 1037), thus providing a simple route to *o*-2-bromoethylbenzyl bromide (cf. Holliman and Mann, *J.*, 1942, 737). This dibromide is the penultimate stage in the synthesis of 1 : 2 : 3 : 4-tetrahydro*iso*arsinolines (Holliman and Mann, *J.*, 1943, 547; Beeby, Cookson, and Mann, *J.*, 1950, 1917) and we have investigated an analogous approach to 4 : 4-disubstituted 1 : 2 : 3 : 4-tetrahydro*iso*arsinolines. We used the α-methyl-α-phenyl compound (II) synthesised by Koelsch, Hochman, and le Claire (*J. Amer. Chem. Soc.*, 1943, **65**, 59), but modified the last two stages of the synthesis. In our hands, formaldehyde was satisfactory and more convenient than pyruvic acid in the hydrolysis of 2-hydroxyimino-3-methyl-3-phenylindan-1-one in spite of a statement to the contrary by these authors. Oxidation of the resulting 1 : 2-dione with hydrogen peroxide was found to be more readily effected by the method of Perkin, Roberts, and Robinson (*J.*, 1912, 234) than by that of Koelsch *et al.*; however, crystallisation of the crude product of this oxidation gives an acid which is always contaminated with the anhydride, so we have converted the product directly into the anhydride before purifying it. Attempts to resolve the acid were unsuccessful and we sought to prepare a derivative of the acid in which one of the carboxyl groups was blocked. With aniline the anhydride gave the *N*-phenylimide whilst with ethanol a mixture of the two monoethyl esters resulted; this mixture was successfully separated, but no attempt was made to orient the two esters.

With lithium aluminium hydride the anhydride gave very satisfactorily 2-*o*-hydroxymethylphenyl-2-phenylpropan-1-ol (III), which with hydrobromic acid under the conditions used by Holliman and Mann (*loc. cit.*) yielded a complex mixture: the main fraction was, unexpectedly, free from bromine, and after purification by chromatography had the formula $C_{16}H_{14}$ arising from the diol by the loss of two molecules of water. It had been expected that conversion of the diol into a dibromide might proceed with rearrangement of the *neo*pentyl type which would give (IV), (V), or (VI). Loss of two molecules of hydrogen bromide, one by ring closure on to the *ortho*-position of the phenyl group, would then be expected to give 9-ethylanthracene from (V); the m. p. of our hydrocarbon, however, was higher than that recorded for 9-ethylanthracene (Bradsher, *J. Amer. Chem. Soc.*, 1940, **62**, 486). An analogous elimination of hydrogen bromide from (IV) and (VI) would yield 3-methyl-1 : 2-5 : 6-dibenzo*cyclo*hepta-1 : 3 : 5-triene (VII). The absorption spectrum of the hydrocarbon showed bands at similar positions to, but with different intensities from, those reported for the methylenedibenzo*cyclo*heptatriene (VIII) (Bergmann *et al.*, *Bull. Soc. chim.*, 1951, 684) and was similar in shape to the spectrum of 1 : 2-diphenylprop-1-ene, but shifted to longer wave-lengths (Ramart-Lucas and Amagat, *ibid.*, 1932, **51**, 108). On the other hand, our spectrum was more closely similar to that of *trans*- rather than *cis*-stilbene (Smakula and Wasserman, *Z. physikal. Chem.*, 1931, *A*, **155**, 353; Lewis, Magel, and Lipkin, *J. Amer. Chem. Soc.*, 1940, **62**, 2973), and, furthermore, non-identity with (VII) was indicated by oxidation with chromic acid to benzoic acid instead of the benzophenone derivative to be expected from (VII) (cf. Treibs and Klinkhammer, *Chem. Ber.*, 1951, **84**, 671). The spectroscopic and degradative evidence suggested that our hydrocarbon might be 3-methyl-2-phenylindene (IX); this supposition was strengthened by the agreement between the m. p. (76—78°) of our compound and that (74—75°) reported for (IX) (*inter al.*, Blum-Bergmann, *Ber.*, 1932, **65**, 109) and confirmed through the m. p. (180—182°) of the hydroxyimino-derivative (Blum-Bergmann, *loc. cit.*, m. p. 184—185°). The absorption spectrum of (IX) has been recorded only above 326 mμ by

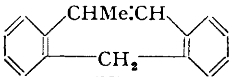


(III)

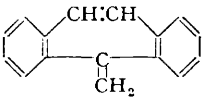
$Br{\cdot}CH_2{\cdot}C_6H_4{\cdot}CMeBr{\cdot}CH_2Ph$
(IV)

$Br{\cdot}CH_2{\cdot}C_6H_4{\cdot}CPhBr{\cdot}CH_2{\cdot}CH_3$
(V)

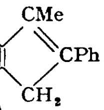
$Br{\cdot}CH_2{\cdot}C_6H_4{\cdot}CH_2{\cdot}CMePhBr$
(VI)



(VII)



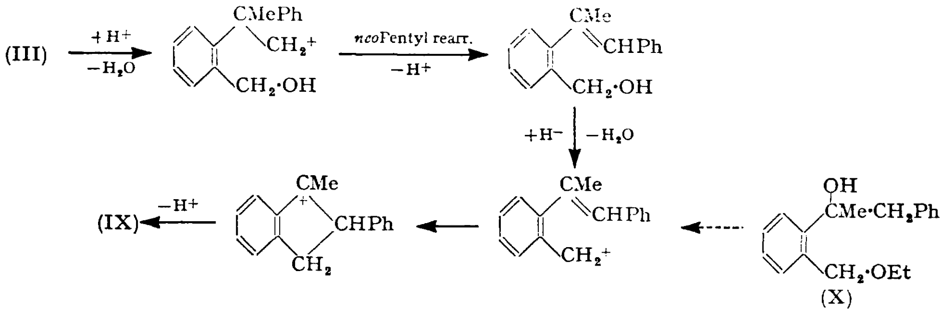
(VIII)



(IX)

Ramart-Lucas and Salmon-Legagneur (*Bull. Soc. chim.*, 1929, **45**, 718) who wrongly considered it to be 9 : 10-dimethylanthracene (Blum-Bergmann, *loc. cit.*); in this region, only end-absorbtion is observed and comparison with our spectrum was of no value.

A possible mechanism for the formation of 3-methyl-2-phenylindene from the diol (III) and involving the attack of a carbonium ion on an olefinic linkage rather than on an aromatic nucleus, is as annexed. Schmerling (*J. Amer. Chem. Soc.*, 1945, **67**, 1152; 1946, **68**, 1650, 1655; 1947, **69**, 1121; 1949, **71**, 698, 701, 753) has shown that alkyl halides add to an olefinic linkage in the presence of aluminium chloride and similar catalysts, probably owing to the initial attack by a carbonium ion on the olefinic system (Alexander, " Ionic Organic Reactions," J. Wiley and Sons, New York, 1950, pp. 143—146); generally, this was followed by addition of the halogen ion, but in a few instances by elimination of a proton, resulting in alkylation of the olefin. Our cyclisation presumably follows the second course on account of the conjugation of the double bond with two aromatic nuclei. On our suggested mechanism it seemed probable that 3-methyl-2-phenylindene would result from the action of hydrobromic acid on other substances which, under these conditions, might be expected to enter this pathway. To test this hypothesis, 2-*o*-ethoxymethylphenyl-1-phenylpropan-2-ol (X) was synthesised. With hydrobromic acid under similar conditions to those used on the diol (III) it gave the hydrocarbon in yield similar to that previously obtained.



These experiments have suggested the possibility of alkylating olefins by means of alcohols in the presence of acids. Preliminary experiments involving stilbene and methyl alcohol in the presence of hydrobromic or sulphuric acid have been unsuccessful but other alcohols and catalysts are being investigated.

EXPERIMENTAL

The stages up to and including 2-hydroxyimino-3-methyl-3-phenylindanone were as described by Koelsch *et al.* (*loc. cit.*).

*3-Methyl-3-phenylindan-*1 : 2*-dione.*—2-Hydroxyimino-3-methyl-3-phenylindanone (265 g.) and 40% aqueous formaldehyde (600 c.c.) were heated, with stirring, with concentrated hydrochloric acid (120 c.c.) for 30 min. on the water-bath, then kept overnight. The orange, solid-containing mixture was heated on the water-bath, with stirring, during 48 hr., formaldehyde and concentrated hydrochloric acid being added from time to time. After cooling, the orange crystalline material was collected, washed well with water, and recrystallised from ethanol (yield 229 g., 92%; m. p. 113—116°).

α-Methyl-α-phenylhomophthalic Anhydride.—A solution of the above diketone (50 g.) in warm methanol (1500 c.c.) was rapidly chilled with vigorous stirring to give a fine suspension. 3% Hydrogen peroxide (500 c.c.) was added, followed (dropwise) by sodium carbonate (30·6 g.) in water (200 c.c.). Chilling and stirring were continued during 3 hr. and the mixture was then set aside overnight. The methanol was removed under reduced pressure and the residue dissolved in water. After extraction with ether, the aqueous solution was combined with aqueous sodium carbonate washings of the ethereal extract, and the mixture was acidified. The precipitated acid was extracted with chloroform, the solvent removed from the extract, and the residue heated at 140° during 3 hr. Recrystallisation of the resulting ***anhydride*** from light petroleum (b. p. 40—60°) gave 35 g. (65%) of colourless prisms, m. p. 67—68·5° (Found: C, 76·0; H, 4·8. $C_{16}H_{12}O_3$ requires C, 76·2; H, 4·8%).

Heating the anhydride with excess of aniline at 160° for 2 hr. and adding hydrochloric acid to the cooled mixture gave a solid which was insoluble in aqueous sodium carbonate solution. Recrystallisation from ethanol gave *α-methyl-α* : N-*diphenylhomophthalimide*, m. p. 114·5—115·5° (Found: C, 80·5; H, 5·2. $C_{22}H_{17}O_2N$ requires C, 80·7; H, 5·2%).

A mixture of the two isomeric *monoethyl esters* of α-methyl-α-phenylhomophthalic acid was prepared (*a*) by refluxing the anhydride with excess of ethanol in the presence of pyridine for 20 hr., and (*b*) by heating the anhydride with excess of ethanol in a sealed tube at 155° for 7 hr. Acidification gave a gum which slowly crystallised, then having m. p. 103—109°. Fractional crystallisation from light petroleum (b. p. 60—80°) gave approximately equal quantities of the two isomeric esters: (i) m. p. 125—127° (Found: C, 72·7; H, 6·2. $C_{18}H_{18}O_4$ requires C, 72·4; H, 6·1%); (ii) m. p. 129·5—132° (Found: C, 72·7; H, 6·2%). The mixed m. p. of (i) and (ii) was 100—116°.

2-o-*Hydroxymethylphenyl*-2-*phenylpropan*-1-*ol*.—A solution of α-methyl-α-phenylhomophthalic anhydride (60 g.) in ether (500 c.c.) was added during 3 hr. to finely powdered lithium aluminium hydride (25 g. of commercial material containing 71% of the active reagent) suspended in ether in the usual apparatus. After refluxing for 3 hr., the mixture was set aside overnight and then hydrolysed with 10% sulphuric acid. The ethereal layer was dried (K_2CO_3), the ether removed, and the residue fractionated to give 55 g. (95%) of the *diol* as a highly viscous, blue-fluorescent glass, b. p. 185—188°/0·6 mm. (Found: C, 79·5; H, 6·8. $C_{16}H_{18}O_2$ requires C, 79·3; H, 7·5%).

The *di*-p-*nitrobenzoate*, prepared in pyridine and recrystallised from ethanol, had m. p. 162—164° with sintering at 132° (Found: C, 67·0; H, 4·5; N, 5·4. $C_{30}H_{24}O_8N_2$ requires C, 66·7; H, 4·5; N, 5·2%).

Action of Hydrobromic Acid on 2-o-*Hydroxymethylphenyl*-2-*phenylpropan*-1-*ol*.—The alcohol (19 g.) was heated with 50% w/v hydrobromic acid in acetic acid (80 c.c.) in a sealed tube at 100° for 11 hr. After cooling, the dark, viscous product was poured into water, the mixture was extracted with ether, and the extract washed with aqueous sodium hydrogen carbonate and dried ($MgSO_4$). The ether was removed and the residue fractionated to give fractions: (*a*) 7 g., b. p. 140—144°/0·6 mm., and (*b*) 3 g., b. p. 160—175°/0·6 mm. Fraction (*b*) gave a positive test for halogen but was non-lachrymatory, and did not yield a definite product. Fraction (*a*) gave a negative test for halogen and eventually crystallised. It was chromatographed in light petroleum on alumina and gave several fluorescent bands. The major band was not strongly absorbed and was eluted in light petroleum, to give 3·5 g. of a crystalline hydrocarbon, m. p. 76—78° after recrystallisation from ethanol (Found: C, 93·3; H, 6·8. Calc. for $C_{16}H_{14}$: C, 93·2; H, 6·8%). The absorption spectrum of an alcoholic solution showed maxima at 228 (ε 10,230) and 294 mμ (ε 19,950), and solutions in light petroleum had a strong blue fluorescence.

2-o-*Ethoxymethylphenyl*-1-*phenylpropan*-2-*ol* (X).—*o*-Bromobenzyl ethyl ether (29 g.) in anhydrous ether (80 c.c.) was converted into the Grignard reagent by using 7·2 g. of activated magnesium powder and 3·6 c.c. of ethyl bromide (Holliman and Mann, *loc. cit.*). Phenylacetone (24 g.; *Org. Synth.*, **16**, 47) in ether (100 c.c.) was added, with stirring, at such a rate that gentle refluxing was maintained. The mixture was refluxed during 3 hr., set aside overnight, and poured on crushed ice and dilute sulphuric acid. The aqueous layer was extracted three times with ether and the combined ethereal solutions were dried (K_2CO_3). Removal of the ether and fractionation of the residue gave 26 g. (69%) of the *alcohol* at 143—144°/0·3 mm. (Found: C, 80·1; H, 8·2. $C_{18}H_{22}O_2$ requires C, 80·0; H, 8·15%).

The alcohol (7 g.) and 50% w/v hydrobromic acid in acetic acid (40 c.c.) were heated in a sealed tube at 100° for 11 hr. The cooled mixture was poured into water and extracted with ether. The ethereal solution was washed with sodium carbonate solution and, after drying ($CaCl_2$), the ether was removed and the product was fractionated. The main fraction (b. p. 130—148°/0·1 mm.; 1·4 g., 26%) solidified, and was recrystallised from alcohol to yield leaflets, m. p. 74—76° unchanged on admixture with 3-methyl-2-phenylindene.

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