714. *The Preparation and Reactions of Some Optically Active Substituted Benzhydrols.*

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The resolution of 2-, 3-, and 4-nitro-, 3,5-dinitro-, and 3-bromo-benzhydrol and the preparation of some optically active aminobenzhydrols are described. Some reactions of the alcohols and their esters involving unimolecular alkyl–oxygen fission have been investigated.

The reactivity of diaryl secondary alcohols and their derivatives has been extensively studied by Kenyon and his collaborators [1] in connexion with alkyl–oxygen heterolysis. Their work included the effect of electron-releasing substituents (*e.g.* 4-methoxy).[2] Nitro- and amino-benzhydrols were of interest in this connexion, the latter also because they might offer a convenient route to other substituted benzhydrols.

2-Nitrobenzhydrol, prepared from 2-nitrobenzaldehyde, was resolved into its optically active forms by crystallisation of its cinchonidine succinate. It was reduced by sodium polysulphide or hydrogen and Adams catalyst, to 2-aminobenzhydrol with varying amounts of 2,2′-bis-α-hydroxybenzylazoxybenzene. The (—)-2-amino-compound gave an *N*-acetyl derivative; with cyanic acid it gave the (—)-2-ureido-alcohol and thence, by cyclis-

[1] Davies, Edwin, Kenyon, and Walsh, *J.*, 1957, 3158.
[2] Balfe, Doughty, Kenyon, and Poplett, *J.*, 1942, 605.

ation, 1,2,3,4-tetrahydro-3-oxo-1-phenylquinazoline. 3- and 4-Aminobenzhydrol were also prepared in active forms, as was the 3,5-dinitro-alcohol. 3-Bromobenzhydrol, prepared from 3-nitrobenzophenone by way of 3-aminobenzophenone, was similarly resolved.

The optical purity of some of these compounds was verified by a series of interconversions. Hydrogen sulphide reduced (—)-3,5-dinitrobenzhydrol to (—)-3-amino-5-nitrobenzhydrol. This was converted into (—)-3-aminobenzhydrol having the same specific rotation as when obtained by direct resolution, and, *via* (—)-3-bromo-5-nitrobenzhydrol, into (—)-3-bromo-benzhydrol of rotation similar to that of the alcohol obtained by resolution of the racemate. (+)-3-Amino- afforded (+)-3-bromo-benzhydrol with numerically the same specific rotation. (+)-2-Amino- afforded (+)-2-chloro-benzhydrol (this compound had previously been partially resolved [3]). Attempts to prepare 4-halogeno-benzhydrols from the 4-amine by the Sandmeyer reaction failed because of the instability of the latter in acid media.[4] It was shown that reduction of nitro- to amino-benzhydrols did not cause racemisation by re-oxidation of (+)-3-amino- to (+)-3-nitro-diphenylmethyl acetate by trifluoroperacetic acid.

The tendency of the alcohols and their esters to react by unimolecular alkyl–oxygen heterolysis was investigated by studying (*a*) hydrolysis of the optically active esters, (*b*) solvolytic reactivity in methanol, acetic acid, and formic acid, and (*c*) reactivity towards toluene-*p*-sulphinic acid.

The optically active hydrogen phthalates of 3- and 4-nitro-, 3,5-dinitro-, and 3-bromobenzhydrol, and the hydrogen succinate of 2-nitrobenzhydrol were hydrolysed by ethanolic sodium hydroxide, and the unpurified alcohols obtained were reconverted into the ester whose specific rotations were within 2% of the original values.

The optically active hydrogen phthalates of 3- and 4-nitro-, 3,5-dinitro-, and 3-bromobenzhydrol, on hydrolysis in 0·2N-sodium hydroxide at room temperature, yielded the optically active alcohols without observable racemisation. No neutral dialkyl phthalate was formed, but from the 4-nitro-ester. 4,4′-Dibenzoylazoxybenzene was also isolated.

The same four optically active hydrogen phthalates and that of the 2-nitro-alcohol, and acetic esters of 3-amino- and 3- and 4-acetamido-benzhydrol, were hydrolysed to the alcohols by an excess of 10% aqueous sodium carbonate under reflux. Only in the last three cases was racemisation observable, the isolated alcohols having optical purities of 90·2%, 92·2%, and 71·5% respectively.

The amino-, acetamido-, and mononitro-alcohols, the hydrogen phthalates of the nitro-alcohols and the bromo-alcohol, and the acetic esters of 3- and 4-nitro- and 4-acetamido-benzhydrol did not react with boiling absolute methanol or suffer thereby observable loss of optical activity. All these alcohols and esters, except 4-aminobenzhydrol, showed a similar lack of reactivity towards boiling 70% aqueous methanol. Both racemic and optically active 4-aminobenzhydrol gave the optically inactive anhydro-form [4] in 40% yield.

The hydrogen phthalates of 3- and 4-nitro-, 3,5-dinitro-, and 3-bromo-benzhydrol, and the hydrogen succinate of 2-nitrobenzhydrol, were unaffected by boiling glacial or 70% acetic acid. These optically active and racemic phthalates with hot 98% formic acid yielded the racemic formates and phthalic acid nearly quantitatively, but the optically active hydrogen phthalate of 2-nitrobenzhydrol, as well as the hydrogen succinate, acetate, and free alcohol, yielded 1,2-di-*o*-nitrophenyl-1,2-diphenylethylene.

The hydrogen phthalates of 3- and 4-nitro-, 3,5-dinitro-, and 3-bromobenzhydrol did not yield sulphones with sodium toluene-*p*-sulphinate in a slight excess of 0·2N-sodium hydroxide, but were hydrolysed at room temperature (the bromo-ester required heating on a water-bath). The hydrogen succinate of 2-nitrobenzhydrol remained unchanged after 12 hr. at 80°. The alcohols obtained from the optically active esters

[3] Balfe, Downer, Evans, Kenyon, Poplett, Searle, and Tárnoky, *J.*, 1946, 797.
[4] Cf. Kippenberg, *Ber.*, 1897, **30**, 1136.

of 3- and 4-nitro- and 3,5-dinitrobenzhydrol showed no significant loss in optical activity. The hydrogen phthalates of 3- and 4-nitro- and 3-bromo-benzhydrol, and the acetates of 4-acetamido- and 3-bromobenzhydrol with sodium toluene-*p*-sulphinate in formic acid yielded the corresponding *p*-tolyl sulphones and phthalic acid. The optically active hydrogen phthalates of 4-nitro- and 3-bromo-benzhydrol, and acetate of the 4-acetamido-alcohol, yielded racemic sulphones. The sulphone from 3-nitrobenzhydrol was also prepared by treating (±)-3-nitrodiphenylmethyl chloride with sodium toluene-*p*-sulphinate in ethanol. The optically active 4-acetamido-acetate with sodium toluene-*p*-sulphinate in 50% aqueous ethanol containing 0·2N-sodium hydroxide gave the racemic *p*-tolyl sulphone and the free 4-acetamido-alcohol showing 23% loss of optical activity.

Although the alcohols (except the 2- and 3-acetamido-compounds) did not react with sodium toluene-*p*-sulphinate in 60% aqueous ethanol, nearly quantitative yields of racemic *p*-tolyl sulphones were obtained from the 2- and 4-amino- and 4-acetamido-alcohols when sodium toluene-*p*-sulphinate was replaced by free toluene-*p*-sulphinic acid. Under these conditions none of the other alcohols reacted, even on prolonged heating at 80°. The racemic 2-amino-sulphone was also obtained by the interaction of the optically active alcohol with toluene-*p*-sulphinic acid in dilute hydrochloric acid. This sulphone with acetic anhydride yielded the 2-acetamido-sulphone; acetylation of the 4-amino-sulphone gave the same product as was obtained by treating 4-acetamidobenzhydrol with toluene-*p*-sulphinic acid in 60% aqueous ethanol.

From the above results, the following order of reactivity towards alkyl–oxygen heterolysis is obtained for benzhydrols: 4-NH_2 > 2-NH_2, 4-NHAc ≫ 3-NH_2, 3-NHAc, 3-Br > 2-, 3-, 4-NO_2, 3,5-$(NO_2)_2$.

The resistance of the nitrobenzhydrols and their esters to alkyl–oxygen heterolysis may be ascribed to the considerable inductive and mesomeric effects of this electron-attracting substituent, which decreases the electron-availability at the alkyl-carbon atom, particularly in the conjugated *ortho*- and *para*-position. This electron-withdrawal by the nitrophenyl group far outweighs the relatively weaker conjugative electron-release to the alkyl-carbon atom by the unsubstituted phenyl group of the benzhydrol molecule. The low solvolytic reactivity of *meta*-substituted benzhydrol and its esters suggests that the inductive effect of the nitro-group is sufficient alone to depress the tendency to alkyl–oxygen heterolysis.

Halogen in *ortho*- or *para*-substituted benzhydrols can exert its electron-releasing mesomeric effect, with consequent increase in electron-availability at the alkyl-carbon atom, and thus may facilitate the heterolysis of the alkyl-carbon–oxygen bond. The tendency of 2-chlorobenzhydrol to alkyl–oxygen heterolysis has previously been demonstrated.[3] The *meta*-halogenobenzhydrols, on the other hand, may be expected to show little tendency to undergo alkyl–oxygen heterolysis as only the adverse inductive effect is operative. The results with 3-bromobenzhydrol support this view.

A pronounced tendency to alkyl–oxygen heterolysis comparable to that of the alkoxybenzhydrols [2] may be expected in benzhydrols substituted with *ortho*- and *para*-amino-groups, in view of the strong electron-releasing mesomeric effect of these substituents. 4,4′-Bisdimethylaminobenzhydrol has been shown [5] to give the phenyl sulphone with sodium benzenesulphinate, to alkylate the active methylene groups in, *e.g.*, ethyl acetoacetate, and to react with other compounds in which the diphenylmethyl cation can displace a proton.[6,7] The results obtained confirm the marked reactivity of benzhydrols with *ortho*- and, particularly, *para*-amino- and -acetamido-groups, in contrast to the relatively unreactive *meta*-compounds. An analogy may be drawn here with the monomethoxybenzhydrols: [2,3] only the *p*-amino-alcohol reacted in aqueous methanol, probably by alkyl–oxygen heterolysis, yielding the polymeric anhydro-form instead of the expected methyl ether. The lower reactivity of the *ortho*-amino-alcohol may be compared with a

[5] Hinsberg, *Ber.*, 1917, **50**, 468.
[6] Möhlau and Heinze, *Ber.*, 1902, **35**, 361.
[7] Humphries, *J.*, 1926, 374.

similar observation for the methoxybenzhydrols,[8] attributed to the more effective contribution of the deactivating inductive effect from the *ortho*- than from the *para*-position. In the case of the amino-alcohol a contributory factor may also be a partial inhibition of the electron-releasing mesomeric effect of the *o*-amino-group due to its restricted ability to assume co-planarity with the ring, or possibly to intramolecular hydrogen-bonding between the amino- and the hydroxy-group.

Experimental

Unless otherwise stated, light petroleum refers to the fraction of b. p. 60—80°. Polarimetric measurements were made in a 4 dcm. tube.

(±)-2-*Nitrobenzhydrol*.—This alcohol, m. p. 63—64° on crystallisation from carbon disulphide (Hey and Mulley [9] give m. p. 59—60°), was prepared (82%) from phenylmagnesium bromide and *o*-nitrobenzaldehyde [10] (Found: C, 68·1; H, 4·8; N, 6·1. Calc. for $C_{13}H_{11}O_3N$: C, 68·1; H, 4·9; N, 6·1%). The *acetate*, prepared (77%) by using acetyl chloride and pyridine, had b. p. 149—151°/0·1 mm., n_D^{25} 1·5728 (Found: C, 66·5; H, 4·8; N, 5·0. $C_{15}H_{13}O_4N$ requires C, 66·4; H, 4·8; N, 5·2%). The *benzoate* (85%), m. p. 92—93°, crystallised in pale yellow prisms from ethanol (Found: C, 72·0; H, 4·6; N, 4·1. $C_{20}H_{15}O_4N$ requires C, 72·1; H, 4·5; N, 4·2%).

The *hydrogen phthalate* prepared by heating the alcohol with phthalic anhydride (1 mol.) and pyridine (1 mol.) crystallised in needles, m. p. 178° (decomp.), from ethyl acetate [Found: C, 66·5; H, 4·4; N, 3·6%; *M* (by titration with NaOH), 375. $C_{21}H_{15}O_6N$ requires C, 66·8; H, 4·0; N, 3·7%; *M*, 377].

(±)-2-Nitrobenzhydrol (0·8 g.) in 98% formic acid (3 ml.) deposited in 24 hr. yellow prismatic crystals (0·4 g.), m. p. 126—127°. Crystallised from ethyl acetate, 1,2-*di*-o-*nitrophenyl*-1,2-*diphenylethylene* (0·3 g.) had m. p. 127° (Found: C, 73·7; H, 4·4; N, 6·5. $C_{26}H_{18}O_4N_2$ requires C, 73·9; H, 4·3; N, 6·6%). This product (0·4 g.) with chromic oxide (0·4 g.) in 90% acetic acid (11 ml.) gave, after purification and crystallisation from ethanol, 2-nitrobenzophenone (0·3 g.), m. p. 105° (Hey and Mulley [9] give m. p. 105°). A similar product was obtained by the action of formic acid on the (±)-acetate, (±)- and (−)-hydrogen phthalate, and (±)-hydrogen succinate.

Resolution. The alcohol (22·9 g.), succinic anhydride (10·0 g.), and pyridine (8·7 g.) were heated on a steam-bath for 1 hr. The product was dissolved in acetone (80 ml.), 5N-hydrochloric acid (40 ml.) and then ice-water (200 ml.) were added, the precipitated oil giving a yellow solid (32 g.), m. p. 128—129°. Two crystallisations from ethyl acetate–light petroleum gave the *hydrogen succinate* (85%), m. p. 131°, pale yellow needles [Found: C, 62·0; H, 4·8; N, 4·2%; *M* (by titration with NaOH), 328. $C_{17}H_{15}O_6N$ requires C, 62·0; H, 4·6; N, 4·3%; *M*, 329].

To the succinate (101 g.) in ethyl acetate (500 ml.) cinchonidine (88·2 g.) was added in small quantities with warming and stirring. The filtered solution deposited two crops of crystals (78 and 20 g.), both of m. p. 126—128°, after 6 and 16 days at room temperature. Seven crystallisations from ethyl acetate gave the last two crops of cinchonidine salt, m. p. 129—130°, which with acid, yielded (+)-2-*nitrodiphenylmethyl hydrogen succinate* of identical rotatory powers. This ester (29·8 g.) had m. p. 69—70°, $[\alpha]_D^{20}$ +99·5° (*c* 3·0 in ethanol) (Found: C, 61·8; H, 4·8; N, 4·4%).

The more soluble cinchonidine salt was decomposed with dilute hydrochloric acid, and the liberated ester was purified (sodium hydrogen carbonate extraction and charcoal), giving a product (47 g.), m. p. 68—85°, $[\alpha]_D^{19}$ −60·2° (*c* 3·0 in ethanol). This in ethyl acetate–light petroleum, when seeded with the (±)-ester, gave, in seven days at 0° practically pure racemic ester (20 g.). Evaporation of the filtrate under reduced pressure gave the (−)-*ester* (26·8 g.), $[\alpha]_D^{20}$ −95·7° (*c* 3·1 in ethanol), as a pale yellow oil which did not solidify [Found: *M* (by titration with NaOH), 326].

To the (+)-ester (20 g.) in ethanol (100 ml.), sodium hydroxide solution (5·1 g. in 20 ml.) was added. After 48 hr. at room temperature, the product was heated to 80° for 1 hr. Water

[8] Davies and Kenyon, *Quart. Rev.*, 1955, **9**, 203.
[9] Hey and Mulley, *J.*, 1952, 2276.
[10] Newman and Smith, *J. Org. Chem.*, 1948, **13**, 596.

(150 ml.) was added to dissolve sodium succinate, and the (−)-*alcohol* which separated was extracted with ether. The ethereal solution was washed successively with sodium hydroxide solution, hydrochloric acid, and water. After evaporation of the dried (Na_2SO_4) ethereal solution the residue was distilled (b. p. 138—140°/0·1 mm.), giving a pale yellow oil (11·8 g.),

Specific rotatory power of (−)-2-*nitrobenzhydrol* (*l*, 1; *t*, 20°).

Solvent	Wavelength (Å) 6438	5893	5461	5086	4800	*c*
C_5H_5N	—	45·6°	—	85·5°	107°	2·047
$MeNO_2$	—	45·5	66·7°	89·0	105	2·029
EtOH	44·6°	66·2	83·4	109	150	2·092
C_6H_6	—	79·8	104	137	178	2·089
$CHCl_3$	—	95·4	136	172	219	2·054
CS_2	—	189	255	330	420	2·010

n_D^{25} 1·6077 (cf. Table) (Found: C, 68·0; H, 4·9; N, 6·0. $C_{13}H_{11}O_3N$ requires C, 68·1; H, 4·9; N, 6·1%).

The (−)-alcohol gave the (+)-*hydrogen phthalate*, m. p. 127°, $[\alpha]_D^{19}$ +95·9° (*c* 2·0 in ethanol), colourless needles from benzene–light petroleum (Found: C, 66·6; H, 4·3; N, 3·8. $C_{21}H_{15}O_6N$ requires C, 66·8; H, 4·0; N, 3·7%).

Obtained similarly from the (−)-succinate, the (+)-*alcohol* had b. p. 141—143°/0·15 mm., n_D^{25} 1·6082, $[\alpha]_D^{20}$ +65·88° (*c* 4·0 in ethanol). This product gave the (−)-*benzoate* (60%), b. p. 192—194°/0·1 mm., n_D^{25} 1·6095, $[\alpha]_D^{19}$ −183·2° (*c* 4·5 in chloroform) (Found: C, 71·9; H, 4·6; N, 4·0. $C_{20}H_{14}O_4N$ requires C, 72·1; H, 4·5; N, 4·2%).

(±)-3-*Nitrobenzhydrol*.—This alcohol, m. p. 68—69°, was prepared (95%) by reduction of 3-nitrobenzophenone with aluminium isopropoxide. The *acetate* (92%), m. p. 78°, crystallised in pale yellow prisms from aqueous ethanol (Found: C, 66·2; H, 4·8; N, 5·3. $C_{15}H_{13}O_4N$ requires C, 66·4; H, 4·8; N, 5·2%). The *benzoate* (80%), m. p. 70—71°, crystallised in colourless needles from ethanol (Found: C, 72·0; H, 4·6; N, 4·0. $C_{20}H_{15}O_4N$ requires C, 72·1; H, 4·5; N, 4·2%). The *hydrogen succinate* (84%), m. p. 106°, formed colourless needles from benzene–light petroleum (Found: C, 62·2; H, 4·7; N, 4·4. $C_{17}H_{15}O_6N$ requires C, 62·0; H, 4·6; N, 4·3%). 3-*Nitrodiphenylmethyl chloride* (69%), b. p. 152—154°/0·3 mm., n_D^{25} 1·6084, was obtained by the interaction of the alcohol with thionyl chloride and pyridine at −10° (Found: C, 62·8; H, 4·3; N, 5·3; Cl, 14·0. $C_{13}H_{10}O_2NCl$ requires C, 63·0; H, 4·1; N, 5·6; Cl, 14·3%).

Resolution. 3-Nitrobenzhydrol (49 g.) was heated with phthalic anhydride (31·7 g.) and pyridine (23 g.) on a water-bath for 1½ hr., cooled, dissolved in acetone (150 ml.), and treated with 5N-hydrochloric acid (60 ml.) followed by ice-water (300 ml.). The (±)-*hydrogen phthalate* (73 g.) crystallised from ethyl acetate–light petroleum in colourless needles, m. p. 150—150·5° [Found: C, 66·9; H, 4·2; N, 3·7%; *M* (by titration with NaOH), 376. $C_{21}H_{15}O_6N$ requires C, 66·8; H, 4·0; N, 3·7%; *M*, 377].

Cinchonine (63·6 g.) was added in portions, with warming and stirring, to a solution of the (±)-phthalate (83·2 g.) in ethanol (350 ml.). The filtered solution, in 6 weeks, deposited a salt (69·3 g.), m. p. 158°, which was recrystallised six times to constant m. p. 175° and $[\alpha]_D^{20}$ +104° (*c* 2·0 in chloroform). Decomposition with hydrochloric acid and three crystallisations from ethyl acetate–light petroleum gave the (+)-*hydrogen phthalate* (43%), m. p. 136°, needles, $[\alpha]_D^{20}$ +15·4° (*c* 5·1 in chloroform) (Found: C, 66·9; H, 4·1; N, 3·8%).

The mother-liquors, on decomposition and removal of the cinchonine, gave a residue (41 g.), which crystallised from ethyl acetate–light petroleum. The filtrate from the first crop (21 g. of almost completely racemic ester) was diluted with light petroleum, and the crude product (35%) was recrystallised thrice from ethyl acetate–light petroleum, giving the (−)-*phthalate*, m. p. 136—137°, $[\alpha]_D^{20}$ −15·5° (*c* 3·6 in chloroform) [Found: *M* (by titration with NaOH), 374. $C_{21}H_{15}O_6N$ requires *M*, 377].

The (+)-hydrogen phthalate with 98% formic acid at 100° for 2 hr. gave the (±)-*formate* (73%), b. p. 154—156°/0·1 mm., n_D^{25} 1·5884 (Found: C, 65·4; H, 4·4; N, 5·3. $C_{14}H_{11}O_4N$ requires C, 65·4; H, 4·3; N, 5·5%). With sodium toluene-*p*-sulphinate (1·07 g.) in 98% formic

acid (7 ml.) at 100° for 3 hr. the (+)-hydrogen phthalate (1·13 g.) yielded (±)-3-*nitrodiphenylmethyl* p-*tolyl sulphone* (0·52 g., 51%), m. p. 133°, pale yellow prisms from aqueous ethanol (Found: C, 65·6; H, 4·7; S, 8·4. $C_{20}H_{17}O_4NS$ requires C, 65·4; H, 4·7; S, 8·7%). An identical product (62%) was obtained by heating (±)-3-nitrodiphenylmethyl chloride with sodium toluene-*p*-sulphinate in ethanol under reflux for 2 hr.

Hydrolysis of the (+)-phthalate (10 g.) with ethanolic sodium hydroxide gave a solid (5·9 g.) which, crystallised from aqueous ethanol, gave colourless needles of the (+)-*alcohol*, m. p. 92° (Found: C, 68·2; H, 4·8; N, 6·1. $C_{13}H_{11}O_3N$ requires C, 68·1; H, 4·9; N, 6·1%) (cf. Table). This gave the (+)-*acetate* (88%), b. p. 162—164°/0·2 mm., n_D^{25} 1·5734, $[\alpha]_D^{21}$ +49·5° (*c* 2·1 in chloroform) (Found: C, 66·1; H, 4·7; N, 5·2. $C_{15}H_{13}O_4N$ requires C, 66·4; H, 4·8; N, 5·2%).

Specific rotatory power of (+)-3-*nitrobenzhydrol* (*l*, 1; *t*, 20°).

Solvent	Wavelength (Å) 5893	5461	5086	4800	*c*
$MeNO_2$	48·9°	62·0°	79·5°	102°	2·064
EtOH	58·1	69·8	81·4	96·4	2·064
$CHCl_3$	64·2	—	90·1	112	2·010
C_6H_6	65·8	79·6	91·3	110	2·036
C_5H_5N	76·9	96·6	117	142	2·133
CS_2	100	126	162	200	1·020

The (−)-alcohol, obtained similarly, had m. p. 92°, $[\alpha]_D^{20}$ −64·0° (*c* 1·9 in chloroform).

(±)-4-*Nitrobenzhydrol*.—This alcohol, m. p. 76—78°, was prepared (88%) by reduction of 4-nitrobenzophenone with aluminium isopropoxide. The *acetate* (91%), m. p. 88—89°, crystallised in colourless needles from ethanol (Found: C, 66·2; H, 4·9; N, 5·5. $C_{15}H_{13}O_4N$ requires C, 66·4; H, 4·8; N, 5·2%). The *hydrogen phthalate* (90%), m. p. 158°, crystallised in colourless needles from benzene [Found: C, 66·5; H, 4·0; N, 4·0%; *M* (by titration with NaOH), 376. $C_{21}H_{15}O_6N$ requires C, 66·8; H, 4·0; N, 3·7%; *M*, 377].

Resolution. To the (±)-phthalate (106 g.) in ethanol (1 l.) quinine (90·4 g.) was added in small quantities with warming and stirring. After filtration and storage for 2 days, the crystals (86 g.) were filtered off and recrystallised from ethanol. The salt (64 g.), m. p. 137—139°, obtained was decomposed by acid in the usual way, giving (+)-4-*nitrodiphenylmethyl hydrogen phthalate* (33 g.), m. p. 131—132°, $[\alpha]_D^{20}$ +37·2° (*c* 4·0 in chloroform), after crystallisation from benzene (Found: C, 66·5; H, 4·0; N, 3·8%). This ester, on reaction with formic acid, gave (±)-4-*nitrodiphenylmethyl formate* (80%), b. p. 153—154°/0·1 mm., n_D^{25} 1·6059 (Found: C, 65·2; H, 4·2; N, 5·5. $C_{14}H_{11}O_4N$ requires C, 65·4; H, 4·3; N, 5·5%). On reaction with sodium toluene-*p*-sulphinate in formic acid, the (+)-phthalate yielded (±)-4-*nitrodiphenylmethyl* p-*tolyl sulphone* (49%), b. p. 173—176°/0·1 mm. (Found: C, 64·8; H, 4·9; N, 3·2; S, 8·4. $C_{20}H_{17}O_4NS$ requires C, 65·4; H, 4·7; N, 3·8; S, 8·7%).

Recovery of the partially optically active phthalate from the mother-liquors from the resolution proved difficult. Hydrolysis of the crude phthalate gave, in varying yields, 4,4′-*dibenzoylazoxybenzene*, m. p. 199—200°, pale yellow plates from benzene (Found: C, 76·9; H, 4·6; N, 7·0. $C_{26}H_{18}O_3N_2$ requires C, 76·8; H, 4·5; N, 6·9%). The *dioxime*, m. p. 220—221° (decomp.), crystallised as yellow needles from aqueous ethanol (Found: C, 71·8; H, 5·0; N, 12·4. $C_{26}H_{20}O_3N_4$ requires C, 71·6; H, 4·6; N, 12·8%). To more of the (±)-phthalate (26·0 g.) in 1 : 2 aqueous acetone (200 ml.) cinchonidine (20·3 g.) was added. After three weeks the salt (23 g.) obtained, m. p. 118—121°, was filtered off, and recrystallised thrice from 1 · 10 aqueous acetone. Decomposition of the final crop (11 g.), m. p. 120—122°, in the usual way, gave the (−)-*hydrogen phthalate* (5·1 g.), m. p. 130—131°, $[\alpha]_D^{20}$ −37·3° (*c* 4·4 in chloroform), after crystallisation from benzene–light petroleum [Found: *M* (by titration with NaOH), 377. $C_{21}H_{15}O_6N$ requires *M*, 377].

Hydrolysis of the (+)- and the (−)-hydrogen phthalate in the usual way gave the (+)-*alcohol*, m. p. 80—81° (cf. Table), pale yellow prisms from benzene (Found: C, 68·2; H, 4·9; N, 6·3. $C_{13}H_{11}O_3N$ requires C, 68·1; H, 4·9; N, 6·1%), and the (−)-*alcohol*, m. p. 80—81°, $[\alpha]_D^{20}$ −77·9° (*c* 2·3 in chloroform), pale yellow prisms from benzene (Found: C, 68·1; H, 4·9; N, 6·2%).

Specific rotatory power of (+)-*4-nitrobenzhydrol* (*l*, 1; *t*, 19°).

Solvent	Wavelength (Å) 5893	5461	5086	4800	*c*
EtOH	50·7°	69·1°	78·0°	86·3°	1·995
C_5H_5N	56·8	69·3	85·3	103	2·005
$MeNO_2$	58·5	69·9	86·3	104	2·017
C_6H_6	74·9	93·9	110	128	2·002
$CHCl_3$	78·2	95·2	114	145	2·060
CS_2	117	150	185	208	2·013

(±)-*3,5-Dinitrobenzhydrol.*—3,5-Dinitrobenzophenone (33 g.) was added to aluminium isopropoxide (17 g.) in isopropyl alcohol (100 ml.), and was heated under reflux with slow distillation (3 drops/min.) for 3 hr. Removal of the solvent and addition of water (150 ml.) and hydrochloric acid (50 ml.) gave an oil which was taken up in ether. The ethereal solution was washed with sodium hydroxide solution and dried (Na_2SO_4). The oil obtained on removal of the ether solidified (m. p. 96—98°). (±)-*3,5-Dinitrobenzhydrol* (32 g.), m. p. 101—101·5°, crystallised from carbon disulphide or benzene–light petroleum in pale yellow needles (Found: C, 56·8; H, 3·8; N, 10·2. $C_{13}H_{10}O_5N_2$ requires C, 56·9; H, 3·7; N, 10·2%). The *acetate* (92%), m. p. 95°, crystallised as pale yellow prisms from ethanol (Found: C, 56·9; H, 3·9; N, 8·9. $C_{15}H_{12}O_6N_2$ requires C, 57·0; H, 3·8; N, 8·9%). The *hydrogen succinate* (86%), m. p. 140°, crystallised as pale yellow prisms from benzene or ethanol (Found: C, 54·8; H, 3·8; N, 7·7. $C_{17}H_{14}O_8N_2$ requires C, 54·5; H, 3·8; N, 7·5%).

Resolution. (±)-3,5-Dinitrobenzhydrol (27·4 g.), phthalic anhydride (14·8 g.), and triethylamine (11·0 g.) were heated on a water-bath for 1 hr. The oil produced, after the usual procedure, soon solidified. The product was washed with water, dried, and crystallised from benzene, giving the *hydrogen phthalate* (38 g.), as needles, m. p. 182° [Found: C, 59·6; H, 3·4; N, 6·7%; *M* (by titration with NaOH), 420. $C_{21}H_{14}O_8N_2$ requires C, 59·7; H, 3·3; N, 6·6%; *M*, 422].

To a hot solution of the hydrogen phthalate (140 g.) in acetone (800 ml.), cinchonidine (97 g.) was added portionwise with stirring. After filtration and storage for 5 days, the crystals (118 g.), m. p. 166—169°, $[\alpha]_D^{20}$ −63·4° (*c* 3·0 in chloroform), were filtered off. Two recrystallisations from acetone gave the pure salt (80 g.), m. p. 170—171°, $[\alpha]_D^{19}$ −64·1° (*c* 3·0 in chloroform). Decomposition of this salt in the usual way gave the (+)-*hydrogen phthalate* (45·5 g.), colourless needles, m. p. 163°, $[\alpha]_D^{20}$ +15·9° (*c* 2·0 in acetone), after three recrystallisations from benzene (Found: C, 59·5; H, 3·4; N, 6·8%). On working up of the mother-liquors, the yield of (+)-phthalate became 65%. Reaction with formic acid gave the (±)-*formate* (88%), m. p 85—86°, colourless needles from ethanol (Found: C, 55·8; H, 3·4; N, 9·3. $C_{14}H_{10}O_6N_2$ requires C, 55·6; H, 3·3; N, 9·3%).

The mother-liquors, containing the more soluble salt, were treated with hydrochloric acid, and the liberated crude ester (68 g.), m. p. 155—160°, was crystallised from benzene, giving a crop (17·2 g.) of practically racemic hydrogen phthalate. The concentrated filtrate deposited the (−)-*hydrogen phthalate* (63%), colourless needles, m. p. 162—163°, $[\alpha]_D^{20}$ −15·8° (*c* 2·1 in acetone) [Found: *M* (by titration with NaOH), 419. $C_{21}H_{14}O_8N_2$ requires *M*, 420].

Hydrolysis of the (−)-hydrogen phthalate by aqueous sodium carbonate (10%) at 100° for 1½ hr. gave the (+)-*alcohol* (92%), m. p. 107° (cf. Table), pale yellow needles from benzene–light

Specific rotatory power of (+)-*3,5-dinitrobenzhydrol* (*l*, 1; *t*, 22°).

Solvent	Wavelength (Å) 5893	5461	5086	4800	*c*
$MeNO_2$	60·6°	73·5°	88·4°	107°	2·046
EtOH	63·6	76·2	91·9	112	2·013
C_5H_5N	83·6	—	—	—	1·986
$CHCl_3$	91·5	108	127	148	2·022
C_6H_6	135	165	197	231	2·004

petroleum (Found: C, 57·3; H, 3·7; N, 10·2. $C_{13}H_{10}O_5N_2$ requires C, 56·9; H, 3·7; N, 10·2%). The (−)-*alcohol* produced similarly from the (+)-hydrogen phthalate, had m. p. 107°, $[\alpha]_D^{19}$ −63·4° (*c* 2·0 in ethanol).

(±)-3-*Bromobenzhydrol.*—This alcohol, m. p. 44°, was prepared from 3-nitrobenzophenone, *via* 3-aminobenzophenone (93%), Sandmeyer reaction (61%) and subsequent reduction (91%) by aluminium isopropoxide. The *acetate* (79%) had b. p. 138—140°/0·3 mm. (Found: C, 59·2; H, 4·5; Br, 25·8. $C_{15}H_{13}O_2Br$ requires C, 59·1; H, 4·3; Br, 26·2%).

Resolution. The alcohol (132 g.), phthalic anhydride (74 g.), and triethylamine (60 g.), by the usual procedure, gave, after crystallisation from acetic acid (90%) or ethyl acetate, the *hydrogen phthalate* (83%), m. p. 142° [Found: C, 61·6; H, 4·0; Br, 19·7%; *M* (by titration with NaOH), 409. $C_{21}H_{15}O_4Br$ requires C, 61·3; H, 3·7; Br, 19·4%; *M*, 411].

To the (±)-hydrogen phthalate (61·6 g.) in ethyl acetate (400 ml.), cinchonine (44·2 g.) was added portionwise with warming and stirring. After filtration and storage for 10 days, an impure dextrorotatory salt (59·4 g.), m. p. 154°, was deposited. Seven recrystallisations from ethyl acetate gave constant $[\alpha]_D^{20}$ +109·0° (*c* 3·6, *l* 2 in chloroform), m. p. 161°. Decomposition of this salt (10·6 g.) in the usual way gave the (+)-*hydrogen phthalate* (5·5 g.), m. p. 127°, $[\alpha]_D^{20}$ +14·95° (*c* 2·0 in chloroform), colourless needles (from ethyl acetate–light petroleum) [Found: C, 61·0; H, 3·9; Br, 19·2%; *M* (by titration with NaOH), 409]. This phthalate on treatment with formic acid gave the (±)-*formate* (78%), b. p. 117—119°/0·1 mm., n_D^{25} 1·5948 (Found: C, 58·0; H, 4·0; Br, 27·3. $C_{14}H_{11}O_2Br$ requires C, 57·8; H, 3·8; Br, 27·5%). Reaction of the (+)-hydrogen phthalate with sodium toluene-*p*-sulphinate in formic acid gave (±)-3-*bromodiphenylmethyl* p-*tolyl sulphone* (75%), m. p. 144°, cubic crystals from methyl acetate (Found: S, 7·9; Br, 19·7. $C_{20}H_{17}O_2SBr$ requires S, 8·0; Br, 19·9%). An identical product was obtained (90%) from (±)-3-bromodiphenylmethyl acetate and sodium toluene-*p*-sulphinate in formic acid.

The mother-liquors, containing the more soluble salt, were decomposed with hydrochloric acid, and the crude solid (24 g.) obtained, on crystallisation from ethyl acetate–light petroleum, yielded a crop (15·1 g.) of practically pure racemic ester. On cooling, the filtrate deposited the (−)-*hydrogen phthalate* (7·2 g.), m. p. 127°, $[\alpha]_D^{20}$ −14·8° (*c* 2·0 in chloroform), colourless needles from 90% acetic acid [*M* (by titration with NaOH), 408. $C_{21}H_{15}O_4Br$ requires *M*, 411]. The (−)-phthalate was also obtained from the (±)-hydrogen phthalate (32·9 g.) and cinchonine (23·5 g.) in acetone (120 ml.). The salt (25·8 g.), m. p. 154—155°, deposited after 5 days, was recrystallised six times from acetone, giving a product (5·5 g.), m. p. 160°. Decomposition of this salt gave a (−)-hydrogen phthalate (3·0 g.), m. p. 127°, $[\alpha]_D^{20}$ −15·1° (*c* 2·1 in chloroform).

Hydrolysis of the (+)-hydrogen phthalate gave the (+)-*alcohol* (92%), colourless needles (from ligroin), m. p. 56°, $[\alpha]_D^{18}$ +32·8° (*c* 2·1 in chloroform) (Found: C, 59·2; H, 4·4; Br, 30·0. $C_{13}H_{11}OBr$ requires C, 59·3; H, 4·2; Br, 30·4%). The (−)-*alcohol*, obtained similarly from the (−)-hydrogen phthalate, had m. p. 56°, $[\alpha]_D^{18}$ −32·4° (*c* 2·2 in chloroform).

2-*Aminobenzhydrol.*—A solution of sodium polysulphide from sodium sulphide (6·0 g.) and sulphur (1·5 g.) in water (20 ml.) was added dropwise to 2-nitrobenzhydrol (2·4 g.) in boiling ethanol (40 ml.), and the mixture was heated under reflux for 1 hr. Ethanol was removed under reduced pressure, 5N-hydrochloric acid (50 ml.) was added, sulphur was filtered off, and the solution was basified with aqueous ammonia. The precipitated oil solidified (1·3 g.; m. p. 110—112°), and on crystallisation from ethanol gave (±)-2-aminobenzhydrol (53%), colourless prisms, m. p. 116° (Gabriel and Stetzner,[11] by reduction of 2-aminobenzophenone, obtained a product, m. p. 120°). 1-α-*Hydroxybenzylphenylazo-2-naphthol*, prepared in the usual way, crystallised from acetic acid (90%) in dark red prisms, m. p. 159—160° (Found: C, 77·9; H, 5·1; N, 7·8. $C_{23}H_{18}O_2N_2$ requires C, 78·0; H, 5·1; N, 7·9%).

A solution of (±)-2-nitrobenzhydrol (2·0 g.) in ethanol (50 ml.), with Adams catalyst (0·10 g.), absorbed the theoretical quantity of hydrogen at room temperature and 5 atm. in 15 min. The filtered solution was concentrated and, on the addition of water, (±)-2-amino benzhydrol (92%), m. p. 115—116°, crystallised. In a second experiment (with 4 g.), apart from aminobenzhydrol (0·8 g.), a neutral substance was isolated by ether-extraction from acid solution. The ethereal solution was washed with sodium hydroxide solution and dried (Na_2SO_4) After removal of the ether, the residue (2·8 g.) crystallised from methanol, giving colourless 2,2′-*di*-(α-*hydroxybenzyl*)*azoxybenzene* (1·8 g.), m. p. 150° (Found: C, 76·1; H, 5·5; N, 6·9 $C_{26}H_{12}O_3N_2$ requires C, 76·1; H, 5·4; N, 6·8%).

(+)-2-*Aminobenzhydrol*, prepared similarly (93%) from (+)-2-nitrobenzhydrol, crystallised from aqueous ethanol in prisms, m. p. 108°, $[\alpha]_D^{19}$ +2·72° (*c* 2·1 in chloroform), $[\alpha]_D^{20}$ −3·55° (*c* 2·0 in ethanol), $[\alpha]_D^{21}$ −25·9° (*c* 2·0 in N-hydrochloric acid) (Found: C, 78·0; H, 6·6; N, 7·1. $C_{13}H_{13}ON$ requires C, 78·4; H, 6·6; N, 7·0%). The (−)-*alcohol* prepared similarly had m. p.

108°, $[\alpha]_D^{20}$ −2·73° (*c* 2·0 in chloroform), $[\alpha]_D^{19}$ +3·6° (*c* 2·0 in ethanol). The (−)-alcohol (1·0 g.) in ethanol (8·5 ml.) was treated with sodium toluene-*p*-sulphinate (1·2 g.), followed by N-hydrochloric acid (5·6 ml.). After 24 hr. the product was filtered off, and crystallisation from aqueous ethanol gave (±)-2-*aminodiphenylmethyl* p-*tolyl sulphone* (88%), m. p. 163° (Found: C, 71·1; H, 5·9; N, 3·8; S, 9·4. $C_{20}H_{19}O_2NS$ requires C, 71·2; H, 5·7; N, 4·1; S, 9·5%). With acetic anhydride, this sulphone gave the (±)-2-*acetamido-compound* (77%), needles, m. p. 192—193° (from methanol) (Found: C, 69·9; H, 5·7; N, 3·6; S, 8·5. $C_{22}H_{21}O_3NS$ requires C, 699; H, 5·6; N, 3·7; S, 8·4%).

A mixture of (−)-2-aminobenzhydrol (1·0 g.) in ether (3 ml.) and acetic anhydride (0·56 g.) was heated on a water-bath for 10 min. After cooling and shaking with 5% sodium hydrogen carbonate solution (50 ml.), an oil was precipitated, which was taken up in ether. The ethereal solution was washed successively with N-sodium hydroxide solution, N-hydrochloric acid, and water, dried (Na_2SO_4), and evaporated. (−)-2-*Acetamidobenzhydrol* (80%) was obtained as a pale yellow oil, $[\alpha]_D^{20}$ −51·1° (*c* 2·0 in chloroform), which set to a glass. It decomposed on attempted distillation at 0·2 mm. (Found: C, 75·1; H, 6·5; N, 5·9. $C_{15}H_{15}O_2N$ requires C, 74·7; H, 6·3; N, 5·8%).

A solution of sodium cyanate (0·78 g.) in water (5 ml.) was added to (−)-2-aminobenzhydrol (1·4 g.) in 5N-hydrochloric acid (5 ml.). A colourless oil was precipitated which solidified and was washed with sodium hydroxide solution and then with water. From aqueous ethanol (−)-2-*ureidobenzhydrol* (82%) crystallised in colourless plates, m. p. 165° (decomp.), $[\alpha]_D^{19}$ −52·4° (*c* 1·0 in methanol) (Found: C, 69·0; H, 5·8; N, 11·5. $C_{14}H_{14}O_2N_2$ requires C, 69·4; H, 5·8; N, 11·6%). Treatment with concentrated hydrochloric acid, gave (±)-1,2,3,4-tetrahydro-3-oxo-1-phenylquinazoline (87%), m. p. 197°, colourless prisms from aqueous ethanol (Gabriel and Stetzner [11] give m. p. 193°).

3-*Aminobenzhydrols.*—(±)-3-Aminobenzhydrol, m. p. 79°, was prepared by sodium polysulphide reduction (70%) or by reduction with Adams catalyst and hydrogen (90%) of the nitro-alcohol. Reduction of (±)-3-nitrodiphenylmethyl acetate by the latter method gave (±)-3-*aminodiphenylmethyl acetate* (70%), which did not crystallise (Found: C, 74·4; H, 6·5; N, 5·7. $C_{15}H_{15}O_2N$ requires C, 74·4; H, 6·3; N, 5·8%). Trifluoroacetic anhydride (5·2 g.) was added to a suspension of 86% w/w hydrogen peroxide solution (1·0 g.) in methylene chloride (40 ml.) cooled in ice. The mixture was stirred for 7 min. and the ice-bath removed. (±)-3-Aminodiphenylmethyl acetate (1·2 g.) in methylene chloride (15 ml.) was added dropwise in 10 min. with vigorous stirring. After being stirred for a further 10 min. the mixture was heated under reflux for 30 min. The cooled product was washed with water, N-sodium carbonate, and water. Removal of the solvent gave a pale yellow oil, which crystallised from aqueous ethanol, giving the (±)-3-nitro-acetate (74%), m. p. and mixed m. p. 77—78°.

(±)-3-*Acetamidobenzhydrol*, prepared as reported for the 2-isomer (78%), crystallised from ethanol in rhombs, m. p. 138° (Found: C, 74·7; H, 6·3; N, 5·7. $C_{15}H_{15}O_2N$ requires C, 74·7; H, 6·3; N, 5·8%).

(+)-3-*Aminobenzhydrol*, obtained by reduction of the (+)-nitro-alcohol (88%), crystallised from aqueous ethanol in colourless prisms, m. p. 106°, $[\alpha]_D^{20}$ +16·76° (*c* 2·0 in chloroform), $[\alpha]_D^{20}$ +2·2° (*c* 1·9 in ethanol) (Found: C, 78·0; H, 6·8; N, 7·0. $C_{13}H_{13}ON$ requires C, 78·4; H, 6·6; N, 7·0%). The (−)-*alcohol* obtained similarly (86%) had m. p. 106°, $[\alpha]_D^{22}$ −16·5° (*c* 2·0 in chloroform). (+)-3-*Aminodiphenylmethyl acetate* (72%), obtained by reduction of the (+)-nitro-acetate, was a thick colourless oil, n_D^{25} 1·5894, $[\alpha]_D^{20}$ +5·55° (*c* 2·0 in chloroform), $[\alpha]_D^{20}$ +1·90° (*c* 3·10 in ethanol) (Found: C, 74·4; H, 6·6; N, 5·9. $C_{15}H_{15}O_2N$ requires C, 74·7; H, 6·3; N, 5·8%). Oxidation with trifluoroperacetic acid gave the (+)-3-nitro-acetate (71%), b. p. 161—164°/0·2 mm., n_D^{25} 1·5730, $[\alpha]_D^{19}$ +48·8° (*c* 2·12 in chloroform). On acetylation, the (+)-3-amino-acetate gave the (+)-3-*acetamido-acetate* (74%), n_D^{25} 1·5851, $[\alpha]_D^{20}$ +7·84° (*c* 2·50 in chloroform) (Found: C, 71·8; H, 5·8; N, 5·0. $C_{17}H_{17}O_3N$ requires C, 72·1; H, 6·1; N, 4·9%). A similar product (77%) was obtained by the acetylation of (+)-3-acetamidobenzhydrol.

(+)-3-*Acetamidobenzhydrol*, prepared in the reported manner (80%), crystallised from ethanol in prisms, m. p.128°, $[\alpha]_D^{20}$ +10·7° (*c* 1·50 in chloroform) (Found: C, 74·8; H, 6·2; N, 5·7. $C_{15}H_{15}O_2N$ requires C, 74·7; H, 6·3; N, 5·8%).

4-*Aminobenzhydrols.*—(±)-4-Aminobenzhydrol, m. p. 121°, was prepared (80%) by reduction of the nitro-alcohol with Adams catalyst and hydrogen. Similarly obtained (89%) from

[11] Gabriel and Stetzner, *Ber.*, 1896, **29**, 1304.

(+)-4-nitrobenzhydrol, (−)-4-*aminobenzhydrol* crystallised in colourless needles (from aqueous ethanol), m. p. 136—137°, $[\alpha]_D^{20}$ −30·3° (*c* 1·12 in chloroform), $[\alpha]_D^{19}$ −38·5° (*c* 2·01 in ethanol) (Found: C, 78·3; H, 6·7; N, 7·1. $C_{13}H_{13}ON$ requires C, 78·4; H, 6·6; N, 7·0%). On heating with 70% aqueous methanol for 10 hr. under reflux, the (−)-alcohol yielded the optically inactive anhydro-form (40%), which separated from ethanol as a yellow amorphous powder, m. p. 235—240° (Kippenberg [4] gives m. p. 220—225°) [Found: C, 85·6; H, 6·3; N, 7·3. Calc. for $(C_{13}H_{11}N)_x$: C, 86·2; H, 6·1; N, 7·7%]. Toluene-*p*-sulphinic acid in aqueous ethanol gave the p-*tolyl sulphone* (95%), m. p. 222°, colourless needles from ethanol (Found: C, 71·3; H, 5·9; S, 9·1. $C_{20}H_{19}O_2NS$ requires C, 71·2; H, 5·7; S, 9·5%). (−)-4-*Acetamidobenzhydrol*, prepared by the method used for the *ortho*-isomer (91%), crystallised from ethanol in colourless plates, m. p. 147°, $[\alpha]_D^{19}$ −16·7° (*c* 2·0 in ethanol) (Found: C, 75·0; H, 6·5; N, 5·7. $C_{15}H_{15}O_2N$ requires C, 74·7; H, 6·3; N, 5·8%). Its (−)-*acetate* (78%) crystallised from aqueous ethanol or benzene–light petroleum in plates, m. p. 122°, $[\alpha]_D^{20}$ −41·3° (*c* 2·0 in ethanol) (Found: C, 72·3; H, 6·2; N, 4·7. $C_{17}H_{17}O_3N$ requires C, 72·1; H, 6·1; N, 4·9%).

This ester, when heated under reflux with an excess of 10% sodium carbonate solution for 3 hr., gave (−)-4-acetamidobenzhydrol, m. p. 143—145°, $[\alpha]_D^{20}$ −11·9° (*c* 2·0 in ethanol); the (−)-acetate obtained on re-esterification had m. p. 120—121°, $[\alpha]_D^{19}$ −30·1° (*c* 2·0 in ethanol). (−)-4-Acetamidobenzhydrol with toluene-*p*-sulphinic acid in aqueous ethanol gave the p-*tolyl sulphone* (83%), m. p. 213°, prisms from ethanol (Found: C, 69·9; H, 5·7; N, 3·5; S, 8·2. $C_{22}H_{21}O_3NS$ requires C, 69·6; H, 5·6; N, 3·7; S, 8·4%). An identical product was obtained (89%) by acetylation of (±)-4-aminodiphenylmethyl *p*-tolyl sulphone, and also (84%) from (−)-4-acetamidodiphenylmethyl acetate and sodium toluene-*p*-sulphinate and formic acid. (−)-4-Acetamidobenzhydrol (1·13 g.) in ethanol (10 ml.) was treated with sodium toluene-*p*-sulphinate (2·14 g.), followed by 0·2N-sodium hydroxide (10·0 ml.), and heated at 80° for 5 hr. Working up in the usual way gave (−)-4-acetamidobenzhydrol (65%), $[\alpha]_D^{20}$ −12·9° (*c* 2·1 in ethanol), and the *p*-tolyl sulphone (22%), m. p. and mixed m. p. 212—213° (from ethyl acetate).

3-*Amino*-5-*nitrobenzhydrol*.—A solution of (±)-3,5-dinitrobenzhydrol (5·0 g.) in ethanol (25 ml.) and aqueous ammonia (8 ml.; *d* 0·880) was cooled in ice and saturated with hydrogen sulphide. The product was heated under reflux for 25 min. and cooled. The saturation and heating were repeated twice, the ethanol was removed under reduced pressure, the residue shaken with 5N-hydrochloric acid (60 ml.), and the sulphur filtered off. The filtered (charcoal) solution was basified with aqueous ammonia, and the precipitated oil extracted with ether. After being washed with water, the dried (Na_2SO_4) solution was evaporated, leaving (±)-3-*amino*-5-*nitrobenzhydrol* (74%) as a glass (Found: C, 64·2; H, 4·3; N, 11·3. $C_{13}H_{16}O_3N_2$ requires C, 64·5; H, 4·2; N, 11·6%). (±)-3-*Benzamido*-5-*nitrobenzhydrol*, prepared in the usual way, crystallised from ethanol in pale yellow needles, m. p. 180° (Found: C, 68·9; H, 4·8; N, 7·9. $C_{20}H_{16}O_4N_2$ requires C, 69·0; H, 4·6; N, 8·0%). (−)-3-Amino-5-nitrobenzhydrol, prepared similarly (70%) from (−)-3,5-dinitrobenzhydrol, did not crystallise and had $[\alpha]_D^{19}$ −51·9° (*c* 1·0, *l* 2 in chloroform). This gave the (−)-N-*benzoate*, m. p. 174°, pale yellow needles (from ethanol), $[\alpha]_D^{22}$ −26·3° (*c* 2·1 in acetone) (Found: C, 68·7; H, 4·8; N, 8·0%).

(+)-2-*Chlorobenzhydrol*.—A solution (5 ml.) of sodium nitrite (0·85 g.) was added with stirring at 0—5° to a solution of (+)-2-aminobenzhydrol (2·2 g.) in concentrated hydrochloric acid (5 ml.) and water (10 ml.). The filtered product was added at 3° to a stirred solution of cuprous chloride (4·4 g.) in 3N-hydrochloric acid (40 ml.). Benzene (50 ml.) was added, and the mixture allowed to reach room temperature with vigorous stirring. After two hr., the product was heated at 80° for 30 min., and the benzene layer was separated and washed successively with water, sodium hydroxide solution, and water. After removal of the solvent, the residue (1·8 g.) was passed in benzene (25 ml.)–light petroleum (50 ml.) through alumina (1 × 10 cm.). The colourless oil (1·6 g.) obtained {$[\alpha]_D^{20}$ +19·8° (*c* 2·6 in ethanol)} did not solidify or crystallise, and was converted, in the usual way, into the (−)-*hydrogen phthalate* (82%), m. p. 140°, colourless needles (from benzene–ligroin), $[\alpha]_D^{20}$ −33·7° (*c* 1·0 in ethanol) [Found: C, 69·1; H, 4·3; Cl, 9·5%; *M* (by titration with NaOH), 364. $C_{21}H_{15}O_4Cl$ requires C, 68·7; H, 4·1; Cl, 9·7%; *M*, 366·7] (Balfe *et al.*[3] report m. p. 69—71°, $[\alpha]_D$ 15·6°, for the partially resolved compound). Hydrolysis of the (−)-phthalate with alcoholic sodium hydroxide solution gave (+)-2-*chlorobenzhydrol*, an oil, $[\alpha]_D^{19}$ +22·0° (*c* 2·0 in ethanol) (Found: Cl, 16·0. $C_{13}H_{11}OCl$ requires Cl 16·2%) (Balfe *et al.*[3] report m. p. 65°, $[\alpha]_D$ +4·7°, for the partially resolved compound). Reconversion of alcohol into the phthalate gave a product, m. p. 139—140°, $[\alpha]_D^{20}$ −32·7° (*c* 1·0 in ethanol).

(±)-2-Chlorobenzhydrol (68%), prepared from (±)-2-aminobenzhydrol and crystallised from ligroin, had m. p. 65—66°.

(+)-3-*Bromobenzhydrol.*—A solution (5 ml.) of sodium nitrite (1·47 g.) was added with stirring at 4° to (+)-3-aminobenzhydrol (3·98 g.) in sulphuric acid (2 ml.) and water (25 ml.). The filtered solution was added in three portions to a well-stirred solution of cuprous bromide (5·75 g.) in 48% hydrobromic acid (25 ml.) and water (50 ml.) at 0°. Working up as before gave a colourless (+)-3-bromobenzhydrol (61%), m. p. and mixed m. p. 55—56° (from ligroin), $[\alpha]_D^{18}$ +32·4° (*c* 2·3 in chloroform).

(−)-3-*Nitrobenzhydrol.*—A solution (5 ml.) of sodium nitrite (0·74 g.) was added at 0—3° to (−)-3-amino-5-nitrobenzhydrol (2·44 g.) in 3N-hydrochloric acid (40 ml.). 5·2N-Hypophosphorous acid (13·5 ml.) was added dropwise at 5° with vigorous stirring to the filtered product. The product was stirred for 4 hr. at room temperature and set aside for 18 hr. Working up as before and crystallisation from carbon disulphide–light petroleum, gave (−)-3-nitrobenzhydrol (54%), m. p. and mixed m. p. 91—92°, $[\alpha]_D^{19}$ −64·1° (*c* 2·1 in chloroform).

(−)-3-*Bromo-5-nitrobenzhydrol.*—A solution (5 ml.) of sodium nitrite (1·47 g.) was added at 0—5° to (−)-3-amino-5-nitrobenzhydrol (4·88 g.) in 48% hydrobromic acid (18 ml.) and water (20 ml.). Cuprous bromide (11·5 g.) in 48% hydrobromic acid (30 ml.) and water (60 ml.) was added with stirring at 3—5°. Benzene (120 ml.) was added, and stirring was continued at room temperature for 1 hr. and then at 50—60° for 3 hr. The benzene layer was washed with sodium hydroxide solution and water, and the solvent removed. The residue was distilled, giving (−)-3-*bromo-5-nitrobenzhydrol* (54%), b. p. 171—173°/0·15 mm., $[\alpha]_D^{22}$ −63·06° (*c* 6·5 in chloroform) (Found: Br, 25·7. $C_{13}H_{10}O_3NBr$ requires Br, 25·9%). The (−)-*hydrogen phthalate* (79%) crystallised as pale yellow rhombs, m. p. 143°, $[\alpha]_D^{19}$ −18·2° (*c* 0·5 in chloroform), from ethyl acetate–light petroleum [Found: Br, 17·2%; *M* (by titration with NaOH), 451. $C_{21}H_{14}O_6NBr$ requires Br, 17·5%; *M*, 456].

(−)-3-*Amino-5-bromobenzhydrol.*—A solution of (−)-3-bromo-5-nitrobenzhydrol (2·0 g.) in ethanol (50 ml.) with Adams catalyst (0·06 g.) absorbed the theoretical quantity of hydrogen at room temperature and 5 atm. in 8 min. The solvent was removed from the filtered solution, and the residue extracted with 2N-hydrochloric acid (15 ml.). The purified (charcoal) extract was neutralised with 2N-ammonia, and the precipitated oil extracted with ether. The ethereal solution was washed with water, dried (Na_2SO_4), and evaporated, leaving (−)-3-*amino-5-bromobenzhydrol* (83%), $[\alpha]_D^{22}$ −17·2° (*c* 2·2 in chloroform), which solidified but could not be crystallised (Found: N, 4·8; Br, 28·3. $C_{13}H_{12}ONBr$ requires N, 5·0; Br, 28·7%). Deamination of this alcohol by the method described gave (−)-3-bromobenzhydrol (58%), m. p. and mixed m. p. 56°, $[\alpha]_D^{20}$ −32·1° (*c* 2·0 in chloroform), $[\alpha]_D^{19}$ −56·6° (*c* 2·0 in carbon disulphide).

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