68. *The Oxidation of Diphenylamine and of its* N-*Derivatives. Part II. Oxidation of the Benzyl Group of Some Benzylamines and Benzyl Ethers to Benzoyl.*

By JAMES FORREST, S. HORWOOD TUCKER, and (MISS) MARGARET WHALLEY.

Oxidation, by means of potassium permanganate in acetone, of several benzyldiphenylamines, the dibenzyltoluidines, and tribenzylamine, and of benzyl ethers, gives the corresponding benzoyl derivatives.

FORREST, LIDDELL, and TUCKER (*J.*, 1946, 454) showed that treatment of *N*-ethyldiphenylamine and of certain of its broom- and nitro-derivatives with potassium permanganate in acetone gives acetodiphenylamides, whilst benzyldiphenylamine yields benzodiphenylamide. Various other diphenylamines either did not react or gave tetraphenylhydrazine.

A number of tertiary amines, $X{\cdot}C_6H_4{\cdot}CH_2{\cdot}NRR'$, containing a benzyl (or substituted benzyl) radical, have now been prepared by heating a secondary or primary amine with benzyl (or substituted benzyl) chloride (A) alone, (B) in the presence of anhydrous potassium carbonate, or (C) in the presence of anhydrous sodium acetate. The addition, in the third method, (C), of a small amount of iodine appeared to have no beneficial effect (cf. Desai, *J. Ind. Inst. Sci.*, 1924, **7**, 235; *Chem. Abstr.*, 1925, **19**, 2645). These tertiary benzylamines were oxidised to the corresponding benzoyl derivatives by potassium permanganate in (*a*) acetone, (*b*) acetone–pyridine, or (*c*) acetone–pyridine–water. Method (*c*) seems to be the best, but it was not used until the work using method (*a*) was nearly complete. Where (*c*) was used it is particuarly mentioned. In Table I the yields mentioned are not strictly comparable since, apart from the difference in the method of oxidation, ease of separation of the product from unchanged starting material varied, of course, from case to case.

TABLE I.

$$X{\cdot}C_6H_4{\cdot}CH_2{\cdot}NRR' \longrightarrow X{\cdot}C_6H_4{\cdot}CO{\cdot}NRR'.$$

	Benzyl derivative.	Benzoyl derivative, yield (method).
1.	*N*-*p*-Nitrobenzyldiphenylamine	70 (*a*)
2.	*N*-*p*-Bromobenzyldiphenylamine	91 (*b*)
3.	*N*-Benzyl-*N*-*p*-nitrobenzylaniline	30 (*c*)
4.	*NN*-Dibenzylaniline	38 (*a*)
5.	*NN*-Dibenzyl-*p*-anisidine	0 (*a*)
6.	*NN*-Dibenzyl-*o*-, -*m*-, and -*p*-toluidine	31, 19, 46 resp. (*a*)
7.	Tribenzylamine	20 (*a*)

N-Benzyl-*N*-methyl- and *N*-benzyl-*N*-ethyl-aniline gave inconclusive results [Method (*a*)].

It is clear that the presence of a *p*-bromo- or a *p*-nitro-group in the benzyl group greatly facilitates oxidation to the corresponding *p*-bromo- or *p*-nitro-benzoyl derivative.

It is noteworthy that in all these oxidations only monobenzoyl derivatives could be isolated, even from di- and tri-benzylamines (Nos. 6 and 7). The contrast between the results under Nos. 4 and 5 is striking.

The constitution of each of the three *N*-benzylbenzotoluidides was established by the synthetic sequence: toluidine ⟶ benzenesulphontoluidide ⟶ *N*-benzylbenzenesulphontoluidide ⟶ *N*-benzyltoluidine ⟶ *N*-benzylbenzotoluidide.

The well-known similarity in behaviour of many nitrogen and oxygen compounds prompted investigation of the oxidation of benzyl ethers by the above methods. Benzyl and substituted benzyl ethers proved somewhat more resistant to oxidation, but gave results comparable with the above. Thus, benzyl phenyl ether by method (*a*) or (*c*) gave a very small yield of phenyl benzoate. Since isolation of this small amount was very difficult, its presence was proved by

TABLE II.

$$X{\cdot}C_6H_4{\cdot}O{\cdot}CH_2Ph \longrightarrow X{\cdot}C_6H_4{\cdot}O{\cdot}COPh.$$

Ether.	Benzoate.	Yield, %.
Benzyl phenyl	Phenyl benzoate	*ca.* 2
p-Bromobenzyl phenyl	Phenyl *p*-bromobenzoate	>26 *
p-Nitrobenzyl phenyl	Phenyl *p*-nitrobenzoate	50
o-Methoxyphenyl *p*-nitrobenzyl	*o*-Methoxyphenyl *p*-nitrobenzoate	10
p-Methoxyphenyl *p*-nitrobenzyl	*p*-Methoxyphenyl *p*-nitrobenzoate	26

* Assessed as *p*-bromobenzoic acid.

alkaline hydrolysis to the acid. Again, the *p*-bromo- and *p*-nitro-benzyl phenyl ethers readily gave the corresponding phenyl *p*-bromo- and *p*-nitro-benzoates, which also were identified by hydrolysis. The *o*- and *p*-methoxyphenyl *p*-nitrobenzyl ethers gave the corresponding benzoyl derivatives in good yield. In Table II, yields are those obtained by oxidation method (*c*), which were invariably higher than those obtained by method (*a*) or (*b*).

Treatment of benzyl phenyl ether with potassium permanganate in aqueous phosphoric acid failed to give an oxidation product (cf. Schmidt and Nieswandt, *Chem. Ber.*, 1949, **82**, 1—oxidation of $\cdot O\cdot CH_2\cdot O\cdot$ to $\cdot O\cdot CO\cdot O\cdot$).

EXPERIMENTAL.

The following descriptions of methods of preparing the required tertiary amines serve to illustrate the procedures adopted. Method (A) has already been described (Forrest, Liddell, and Tucker, *loc. cit.*).

N-p-*Bromobenzyldiphenylamine.—Method* (B). Diphenylamine (6 g., 1 mol.), *p*-bromobenzyl bromide (Weizmann and Patai, *J. Amer. Chem. Soc.*, 1946, **68**, 150) (6·3 g., 1 mol.), and anhydrous potassium carbonate (4·5 g., 1·3 mols.) were heated together at 175° (in a flask connected to a eudiometer) until no more carbon dioxide was evolved (2·5 hours). The reaction mixture was treated with water and extracted with ether, the ether removed, and the semi-solid residue washed with 70% (v/v) aqueous ethanol to remove unchanged diphenylamine. Crystallisation from ethanol gave sword-blade crystals of N-p-*bromobenzyldiphenylamine*, m. p. 83—84° (4·6 g., 55%) (Found : C, 67·3; H, 4·7. $C_{19}H_{16}NBr$ requires C, 67·45; H, 4·7%).

Method (C), *Desai's modification* (loc. cit.). Diphenylamine (4·2 g.), *p*-bromobenzyl bromide (6·3 g.), anhydrous sodium acetate (2 g.), and iodine (0·02 g.) gave *N*-*p*-bromobenzyldiphenylamine (4·7 g., 56%). Generally, the addition of iodine in similar preparations appeared to have no effect. *N*-*p*-Bromobenzyldiphenylamine became bluish-green in air, but remained colourless in a sealed glass tube.

N-p-*Nitrobenzyldiphenylamine*. Method (*B*), carried out at 155° for 3 hours, gave lustrous plates (from light petroleum, b. p. 60—80°; then methanol), m. p. 92—94° (51%) [Desai, *loc. cit.*, claimed a 70% yield of a compound insoluble in light petroleum, with m. p. 93·5°. Using his method, we confirmed our results (52%). Lyons, *J. Amer. Pharm. Assoc.*, 1932, **21**, 224, gives m. p. 96°].

N-*Benzyl*-N-p-*nitrobenzylaniline.—Method* (B). *N*-Benzylaniline (1 mol.), *p*-nitrobenzyl chloride (1·1 mols.), and anhydrous potassium carbonate (2 mols.) were heated at 150° for 3—4 hours, the mass was then treated with water, and the insoluble solid crystallised (from acetic acid, then ethyl acetate) as lemon-yellow needles, m. p. 143—144° (70%) (Found : C, 75·6; H, 5·9; N, 8·9. $C_{20}H_{18}O_2N_2$ requires C, 75·5; H, 5·7; N, 8·9%).

N-*Benzyl*-N-*ethylaniline picrate* formed lemon-yellow, hexagonal prisms (from benzene), m. p. 126—128°, softening at 120° (Found : C, 57·1; H, 4·4; N, 12·6. $C_{15}H_{17}N,C_6H_3O_7N_3$ requires C, 57·3; H, 4·5; N, 12·7%).

Benzamides.—(A) *By oxidation.* (i) *Method* (a) (Forrest, Liddell, and Tucker, *loc. cit.*). The following were thus obtained : *p*-nitrobenzodiphenylamide, pale yellow prisms (from ethanol), m. p. 152—154° (70%) (Chapman, *J.*, 1927, 1749, gives m. p. 156—157°) (Found : C, 72·0; H, 4·6; N, 9·0. Calc. for $C_{19}H_{14}O_3N_2$: C, 71·7; H, 4·4; N, 8·8%); *N*-benzylbenzanilide, m. p. 103—104° (38%); N-*benzylbenzo*-o-*toluidide*, prisms (from light petroleum, b. p. 40—60°), m. p. 65—67° (31%) (Found : C, 82·2, 82·2, 82·4; H, 6·3, 6·3, 6·6; N, 4·5. $C_{21}H_{19}ON$ requires C, 83·7; H, 6·3; N, 4·7%); *N*-benzylbenzo-*m*-toluidide, stout prisms (from light petroleum, b. p. 60—80°), m. p. 70—71° (19%) (Grunfeld, *Bull. Soc. chim.*, 1937, [v], **4**, 654, gives m. p. 69°) (Found : C, 83·8; H, 6·3; N, 4·6%); *N*-benzylbenzo-*p*-toluidide, stout prisms (from methanol), m. p. 124—125° (46%) (Found : C, 83·85; H, 6·5; N, 4·7%) (Rabaut, *Bull. Soc. chim.*, 1891, [iii], **6**, 139, found m. p. 87—88°). Tribenzylamine on oxidation gave *NN*-dibenzylbenzamide (20%).

(ii) *Method* (b). This is exemplified by the following. *N*-*p*-Bromobenzyldiphenylamine (1 g.) in acetone (20 ml.) and pyridine (2 ml.) was treated with finely-powdered potassium permanganate (2·5 g.) portionwise, the mixture being boiled after each addition until the permanganate colour nearly vanished (45 minutes in all). The stirred mixture was boiled for an hour and then treated with a solution of sodium pyrosulphite in dilute sulphuric acid, and the product crystallised from methanol to give faintly yellow sword-blade prisms, m. p. 143—145° (0·95 g., 91%), of p-*bromobenzodiphenylamide* (Found : C, 65·0; H, 4·3; N, 4·2; Br, 23·3. $C_{19}H_{14}ONBr$ requires C, 64·8; H, 4·0; N, 4·0; Br, 22·7%). This was boiled with ethanolic potassium hydroxide for 0·5 hour, water was added, and the solution extracted with ether. The aqueous fraction on treatment with hydrochloric acid gave a pale bluish solid which crystallised from acetic acid in rectangular laminæ, m. p. 248—249°, undepressed on admixture with *p*-bromobenzoic acid (Found : C, 41·9; H, 2·5. Calc. for $C_7H_5O_2Br$: C, 41·8; H, 2·5%).

(iii) *Method* (c). This is exemplified by the following. *N*-Benzyl-*N*-*p*-nitrobenzylaniline (0·5 g.), acetone (10 ml.), pyridine (0·2 ml.), water (0·2 ml.), and potassium permanganate (0·5 g., added all at once) were boiled together for 20 minutes, and the product was worked up as above. Unchanged material (0·07 g.) was left as yellow needles when the precipitated oxidation product was boiled with methanol; the evaporated extract, recrystallised from benzene–light petroleum (b. p. 60—80°), gave N-*benzyl*-p-*nitrobenzanilide*, m. p. 120—122° (0·16 g., 30%) (Found : C, 72·3; H, 5·0; N, 8·3. $C_{20}H_{16}O_3N_2$ requires C, 72·3; H, 4·8; N, 8·4%).

(B) *By benzoylation.* This provided specimens for comparison. *E.g.*, *p*-bromobenzoic acid (5 g.) was heated on a water-bath with phosphorus pentachloride (1·7 g.) for 3·5 hours : a solution of diphenylamine (4·2 g.) in pyridine (10 ml.) was added and the mixture heated for 0·5 hour. The pyridine was removed under reduced pressure, and the residue acidified with 20% hydrochloric acid to give pale yellow prisms (from methanol) (6·0 g., 57%), m. p. 143—145°, alone or on admixture with the product obtained by oxidation. Standard methods gave N-*methyl*-, faintly brown plates [from benzene–light petroleum (b. p. 60—80°)], m. p. 103—106° (Found: C, 65·6; H, 4·8; N, 11·1. $C_{14}H_{12}O_3N_2$ requires C, 65·6; H, 4·7; N, 10·9%), and *N*-ethyl-*p*-nitrobenzanilide, pale brown, diamond-shaped crystals [from benzene–light petroleum (b. p. 60—80°)], m. p. 115—117° (softening at 111°) (Lockemann, *Ber.*, 1942, **75**, 1917, found m. p. 119—120°) (Found: C, 67·0; H, 5·2; N, 10·4. Calc. for $C_{15}H_{14}O_3N_2$: C, 66·7; H, 5·2; N, 10·4%). The action of *p*-nitrobenzoyl chloride on *N*-benzylaniline gave *N*-benzyl-*p*-nitrobenzanilide, m. p., alone or on admixture with the compound prepared as above by the oxidation of *N*-benzyl-*N*-*p*-nitrobenzylaniline, 120—122°.

Syntheses of N-*Benzylbenzotoluidides*.—The *N*-benzenesulphontoluidide (10 g.) was dissolved in the theoretical amount of N-sodium hydroxide, and the calculated amount of benzyl chloride (redistilled in a vacuum) was added slowly to the stirred solution, at 40—45° during 1·5 hours; ethanol (50 ml.) was then introduced, and the mixture refluxed (1·5 hours). The oil which separated crystallised slowly on cooling, and was recrystallised from ethanol. Thus were obtained N-*benzylbenzenesulphon*-o-, needles, m. p. 107—109° (8·0 g., 58%) (Found: C, 71·2; H, 5·6. $C_{20}H_{19}O_2NS$ requires C, 71·2; H, 5·7; N, 4·15%), -m-, needles, m. p. 102—105° (4·5 g., 32%) (Found: C, 71·2; H, 5·6%), and *p*-toluidide, prisms, m. p. 121—122° (8 g., 58%) (Apitzsch, *Ber.*, 1900, **33**, 3524, gives m. p. 123—124°) (Found: C, 71·5; H, 5·8; N, 4·3%).

The *N*-benzylbenzenesulphontoluidide (2 g.) was warmed with 60% sulphuric acid (2 ml.) at 125° for 1 hour (cf. Apitzsch, *loc. cit.*). The solution was poured into water, filtered, and basified with sodium hydroxide solution. The oil which separated was shaken with benzoyl chloride and sodium hydroxide solution, giving *N*-benzylbenzo-*o*- (0·1 g., 5%), -*m*- (0·4 g., 20%), and -*p*-toluidide (0·15 g., 8%).

Benzyl Ethers and Their Oxidation Products.—The benzyl ethers were prepared by interaction of the appropriate benzyl chloride or bromide and the sodium phenoxide (cf. Powell and Adams, *J. Amer. Chem. Soc.*, 1920, **42**, 657). Benzyl *o*-methoxyphenyl ether had m. p. 57—58° (Claisen, *Annalen*, 1925, **442**, 244, gives m. p. 62°, and Birch, *J.*, 1947, 104, m. p. 58—59°); the *p*-isomer had m. p. 66—68° (cf. Smith, *J.*, 1931, 256). The following are new: *methyl* m-*benzyloxybenzoate*, stout prisms (from ethanol), m. p. 68—70° (Found: C, 74·6; H, 5·8. $C_{15}H_{14}O_3$ requires C, 74·4; H, 5·8%), and the p-*isomer* (from ethanol), m. p. 98—100° (Found: C, 74·2; H, 5·7%); o-*methoxyphenyl* p-*nitrobenzyl ether*, pale brown prisms (from methanol), m. p. 64—65° (Found: C, 65·1; H, 5·3; N, 5·5. $C_{14}H_{13}O_4N$ requires C, 64·9; H, 5·05; N, 5·4%), and its p-*isomer*, pale yellow prisms (from methanol), m. p. 86—88° (Found: C, 65·0; H, 5·1; N, 5·4%).

Oxidation was by the standard procedures adopted for the oxidation of the amines; but the best results were obtained by using the ether (0·5 g.), acetone (10 ml.), pyridine (0·2—0·5 ml.), water (0·2—0·5 ml.), and potassium permanganate (0·5—1·0 g., added all at once), boiling being continued for 2—5 hours until practically all permanganate colour had disappeared. Thus benzyl phenyl ether gave, after removal of unchanged ether by repeated crystallisation from methanol and finally from light petroleum (b. p. 40—60°), stout rods, m. p. 67—68°, of phenyl benzoate (1—2%). Since this could not be invariably repeated, the residue obtained after removal of most of the unaltered ether was hydrolysed by boiling it with sodium hydroxide (0·1 g.) in ethanol (5 ml.) for 1 hour, and worked up in the usual way to give benzoic acid, m. p. and mixed m. p. 120—122°. Similarly, *p*-nitrobenzyl phenyl ether, by the above modified method (2·25 hours), gave, after the usual treatment with sulphurous acid solution, phenyl *p*-nitrobenzoate, m. p. 125—127° (from methanol) (50%); this was hydrolysed to *p*-nitrobenzoic acid, m. p. 235° (lit., 242°). *p*-Bromobenzyl phenyl ether similarly gave phenyl *p*-bromobenzoate—not isolated, but hydrolysed to *p*-bromobenzoic acid (26%), m. p. and mixed m. p. 248° (lit., 251°). *o*-Methoxyphenyl *p*-nitrobenzyl ether on oxidation gave faintly green material, which by fractional crystallisation from methanol gave starting material and o-*methoxyphenyl* p-*nitrobenzoate* (10%), m. p. 102—104° (Found: C, 61·4; H, 4·2; N, 5·0. $C_{14}H_{11}O_5N$ requires C, 61·5; H, 4·1; N, 5·1%). Similarly was obtained p-*methoxyphenyl* p-*nitrobenzoate*, needles (from ethanol), m. p. 113—115° (26%) (Found: C, 61·9; H, 4·0; N, 4·5%); hydrolysis of the *o*-ester gave an unworkable black solution.

We are indebted to the Department of Scientific and Industrial Research for a Grant to one of us (M. W.), and to Mr. W. M. O. Rennie, B.Sc., for assistance; also to Mr. J. M. L. Cameron and to Miss R. H. Kennaway for microanalyses.

UNIVERSITY OF GLASGOW. [*Received, October 5th,* 1950.]