LANDER : SYNTHESIS OF IMINOETHERS.

XXXII.—Synthesis of Iminoethers. N-Ethyl, N-Methyl, and N-Benzyl Benziminoethers.

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AMONGST the open chain nitrogen substituted iminoethers of the type $R_1C(OR_{11}):NR_{111}$ we are at present acquainted only with those in which R_{111} is an aryl group. It seemed therefore of interest to undertake the preparation of the *N*-alkyl and benzyliminoethers. Benziminoethers of this class are described in the present paper.

Of the methods available for their formation from the acylated amines (Trans., 1901, 79, 690; and 1902, 81, 591) that of alkylation by means of dry silver oxide and alkyl iodides has proved of no practical value. In a test experiment, 7.5 grams of benzethylamide after boiling for 3 hours with 23 grams of dry silver oxide and 32 grams of ethyliodidegave only 0.5 gram of N-ethylbenziminoethyl ether. The failure of the reaction is doubtless attributable to the diminished acidity of the substituted amide caused by the introduction of the relatively basic alkyl group. Recourse had therefore to be taken to the method of synthesis from the imide chlorides by the action of sodium alkyloxides, a process which leads to the formation of the desired products, in a manner generally similar to that previously described for the aryl benzamides.

EXPERIMENTAL.

I. N-Ethylbenziminoethers.

The imide chloride of benzethylamide, $Ph\cdot CCI:NEt$, has not previously been described. It is formed similarly to the methyl analogue (Pechmann, Ber., 1895, 28, 2367) by the interaction of phosphorus pentachloride and benzethylamide in molecular proportion. After distilling off the phosphorus oxychloride under diminished pressure, the imide chloride boils at 110—111° under 15 mm. pressure, forming a colourless limpid liquid. The first portions of the distillate contain a solid (compare Pechmann, loc. cit.), which subsequently volatilises out of the warm distillate.

The imide chloride was not analysed, its identity being established by the following reactions: the regeneration of benzethylamide by the action of water, the formation of iminoethers through the agency of sodium alkyloxides, and the production of *phenylethylbenzenylamidine* by condensation with aniline. When aniline was added to a solution of the imide chloride in light petroleum, the hydrochloride of this amidine was deposited as a sticky mass, which was extracted with dilute sulphuric acid. On adding potassium iodide the hydriodide of the amidine was precipitated as a brown resin from which the base was obtained by decomposition with sodium carbonate. After two crystallisations from dilute alcohol it formed small colourless needles (m. p. $74-76^{\circ}$).

The platinichloride is sparingly soluble in water and is deposited from dilute alcohol in yellow prisms which decompose at 204° .

0.5486 lost 0.0221 at 100° and gave 0.1200 Pt. $\rm H_2O=4.02$; $\rm Pt=22.8.$

 $(Ph \cdot C: NEt \cdot NHPh)_2, H_2PtCl_6, 2H_2O$ requires $H_2O = 4.03$; Pt (in the dry salt) 22.71 per cent.

The work of Pechmann on mixed amidines (*loc. cit.*) leaves no doubt that the constitution of the above base is expressed by the formula $Ph \cdot C(:NEt) \cdot NHPh$ and not $Ph \cdot C(:NPh) \cdot NHEt$.

N-Ethylbenziminoethyl ether, Ph·C(OEt):NEt, constitutes the main product of the action of sodium ethoxide on a light petroleum solution of the imide chloride. Benzoyl diethylbenzenylamidine (Trans., 1902, 81, 594), isolated in the preparation of the methyl-iminoether, is doubtless also formed. The iminoether is, however, contaminated with some unrecognised impurity. In one case, the imide chloride was separated by distillation under diminished pressure into two fractions boiling at 118-124° and 124-125° respectively, and these, freed as far as possible from solid (see above) by solution in light petroleum, were separately treated with an alcoholic solution of sodium ethoxide, and the resulting iminoether isolated by distillation under diminished pressure in a manner similar to that formerly employed. In each instance, the iminoether distilled between 105° and 115° under 15 mm. pressure, and each of the two products was then divided into three fractions by distillation at the ordinary pressure, the total yield of distilled product from 30 grams of benzethylamide being 17 The extreme boiling points were 215° and 227°, and repeated grams. analysis showed that none of the fractions was pure. Fractions boiling at $218-221^{\circ}$ and $223-227^{\circ}$ gave C = 73.56, H = 8.54, and C = 71.3, H = 8.3 respectively, the formula $C_{11}H_{15}ON$ requiring C = 74.57, H = 8.47 per cent.

Boiling point and composition alike indicated that a liquid of higher boiling point and smaller carbon content than the iminoether was probably present. Fractionation with the comparatively small quantity of substance available did not lead to a separation. It seemed, however, not unlikely that the impurity might be a compound of the formula $Ph^{\circ}C(OEt)_2 \cdot NHEt$. Open chain mixed ortho-compounds of this type have not been hitherto obtained. I have, however, recently prepared such derivatives corresponding with the oxanilic esters, the formation and properties of which I hope soon to be able to communicate. It might be supposed that an ortho-compound of the type indicated would readily lose alcohol on heating, giving an iminoether; that this is not necessarily the case is shown by the oxalic compounds above referred to.* And although the compound $Ph \cdot C(OEt)_2 \cdot NHEt$ is more likely to lose alcohol on distillation (compare p. 325), it is still possible that the change might not be complete. The elimination of alcohol would probably be facilitated by warming with a dehydrating agent, and acetic anhydride, which does not appear to react with this class of nitrogen substituted iminoethers, seemed to be the most suitable.

Impure N-ethylbenziminoethyl ether (9.5 grams) boiling at $219-226^{\circ}$ was mixed with 0.6 gram of acetic anhydride and warmed in an oilbath. At about 160°, the liquid began to boil and the odour of ethyl acetate was distinctly perceptible. The warming was continued for a few minutes and, after cooling, moderately concentrated potassium hydroxide solution was added.

The iminoether was extracted with ether, dried with calcium chloride, and distilled under 12 mm. pressure, when two fractions $106-107^{\circ}$ and $107-109^{\circ}$ were obtained. The second fraction was analysed:

0.1334 gave 0.3636 CO₂ and 0.1015 H_2O . C = 74.33; H = 8.45. C₁₁ $H_{15}ON$ requires C = 74.57; H = 8.47 per cent.

The purified compound, which was analysed after distillation, boiled at $221-223^{\circ}$ (uncorr.) under the ordinary pressure :

0.1339 gave 0.3650 CO₂ and 0.1020 H₂O. C = 74.34; H = 8.46.

A second treatment with 1/10 molecular proportion of acetic anhydride yielded a product boiling at 105° under 11 mm. pressure, and giving C=74.31, H=8.59. Nitrogen was determined in this specimen:

0.1300 gave 9.0 c.c. moist nitrogen at 13° and 750 mm. N = 8.05. $C_{11}H_{15}ON$ requires N = 7.9 per cent.

N-Ethylbenziminoethyl ether is a limpid, colourless liquid, with a pungent odour recalling that of the alkylamines. Anhydrous hydrogen chloride precipitates an oily hydrochloride from petroleum solution, which yields ethyl chloride and benzethylamide on heating. Aqueous hydrochloric acid brings about the usual resolution into ethyl benzoate and amine.

* The compound $CO_2Me \cdot C(OMe)_2 \cdot NHPh$, for example, distils unchanged in a vacuum, and, on heating under the ordinary pressure, undergoes profound decomposition.

By warming with aniline at 100° for 3 hours, phenylethylbenzenylamidine (m. p. 74—76°) is produced, the product being identical in all respects with that prepared from the imide chloride.

N-Ethylbenziminomethyl ether, Ph·C(OMe):NEt.—Thirty grams of imide chloride were obtained from 30 grams of benzethylamide and 42 grams of phosphorus pentachloride and this product, which required 3.8 grams of sodium dissolved in methyl alcohol, gave 20 grams of crude N-ethylbenziminomethyl ether. After treatment with acetic anhydride (0.1 mol.) the iminoether distilled between 97° and 100° under 11 mm. pressure:

0.1186 gave 0.3180 CO₂ and 0.0875 H₂O. C=73.12; H=8.19. $C_{10}H_{13}ON$ requires C=73.62; H=7.97 per cent.

A specimen, purified by repeating this treatment, was also analysed :

0.1240 gave 0.3330 CO₂ and 0.0891 H₂O. C = 73.23; H = 7.98.

The boiling point under the ordinary pressure is 209-212° (uncorr.). Benzoyldiethylbenzenylamidine, Ph·C(:NEt)·NEt·COPh, was slowly deposited from a chloroform solution of the yellow gummy residue left after distillation of the crude iminoether; it separates in dense, colourless prisms, which, after two crystallisations from chloroform and ether, melt without decomposition at 90-91.5°:

This compound is a base, in which respect it differs from the benzoylated arylbenzenylamidines which are neutral bodies, and resembles benzoylbenzamidine (Eitner, *Ber.*, 1892, 25, 467). It is readily soluble in cold dilute hydrochloric acid and is reprecipitated unchanged by alkalis. The *platinichloride*, which is precipitated in minute orange prisms when platinic chloride is added to a solution of the base in hydrochloric acid, is anhydrous, and decomposes at $151-151\cdot5^{\circ}$.

0.3672 gave 0.0746 Pt. Pt = 20.3. {Ph·C(:NEt)·NEt·COPh}, H, PtCl_a requires Pt = 20.1 per cent.

On prolonged standing, and more rapidly on warming, the solution of the benzoylated amidine in hydrochloric acid undergoes decomposition. Benzoic acid and ethylamine could be detected, and a neutral compound, melting at $101-102^{\circ}$ after crystallisation from dilute alcohol, was also formed, but in quantity insufficient for analysis.

II. N-Methylbenziminoethers.

N-Methylbenziminomethyl ether, Ph·C·(OMe):NMe.— The imide chloride of benzmethylamide has been described by Pechmann (*loc. cit.*), who failed to obtain it in a state of purity, and regarded it as contaminated with an impurity of higher boiling point, which is free from chlorine.

For the preparation of the iminoether, the imide chloride may first be distilled, or the residue left after removal of phosphorus oxychloride from the product of reaction of the pentachloride with benzmethylamide may be dissolved in benzene and treated with sodium methoxide in alcoholic solution. In either case an impure iminoether results, with benzoyldimethylbenzenylamidine as a by-product.

The boiling point and analytical data of the iminoether were similar to those of N-ethylbenziminoethyl ether, indicating the presence of a similar impurity, and treatment with acetic anhydride was found to effect the required purification. After warming twice with acetic anhydride (0·1 mol.) the iminoether was obtained in a pure state and distilled almost completely at $94-95^{\circ}$ under 12 mm., and at $203-206^{\circ}$ (uncorr.) under the atmospheric pressure :

0.1274 gave 0.3380 CO₂ and 0.0866 H₂O. C = 72.35; H = 7.55. 0.1116 , 0.2958 CO₂ , 0.0750 H₂O. C = 72.28; H = 7.46. C₉H₁₁ON requires C = 72.48; H = 7.38 per cent.

The compound is a colourless, limpid liquid of amine-like odour. Ethereal hydrogen chloride gave an impure hydrochloride melting at $65-70^{\circ}$, with evolution of methyl chloride and regeneration of benzmethylamide.

On warming some of the iminoether with aniline at 100° for 6 hours, phenylmethylbenzenylamidine melting at $132-134^{\circ}$ was formed (compare Pechmann, *loc. cit.*).

Benzoyldimethylbenzenylamidine, Ph·C(:NMe)·NMe·COPh, was isolated from the product of reaction of the imide chloride with sodium methoxide, in the manner already described; after crystallisation from chloroform and light petroleum, it formed colourless prismatic crystals melting at $116-117.5^{\circ}$:

0.1360 gave 0.3796 CO₂ and 0.0804 H_2O . C = 76.12; H = 6.56.

0.1220 , 11.8 c.c. moist nitrogen at 15° and 758 mm. N = 11.27. C₁₆H₁₆ON₂ requires C = 76.19 ; H = 6.35 ; N = 11.11 per cent.

Like its ethyl analogue, this compound is a base. The platinichloride forms anhydrous, orange-coloured prisms decomposing at $184-185^{\circ}$:

0.5256 gave 0.1124 Pt. Pt = 21.38.

 $(C_{16}H_{16}ON_2)_2H_2PtCl_6$ requires Pt = 21.31 per cent.

N-ETHYL, N-METHYL, AND N-BENZYL BENZIMINOETHERS. 325

On warming with dilute hydrochloric acid, the base yields methylamine, benzoic acid, and a neutral solid melting at 91-95° which has not yet been examined.

Attempt Prepare the Ortho-compound, Ph·C(OMe), NHMe.to When molecular proportions of phosphorus pentachloride and benzmethylamide are mixed in the cold, and care is taken to avoid overheating, a slight rise of temperature is observed, and the mass melts without evolution of hydrogen chloride. On cooling, the brown syrup becomes fillel with needle-shaped crystals, which almost certainly consist of the amide chloride, Ph·CCl, NHMe, but the substance liquefies on exposure for a few seconds to moist air, so that neither the melting point nor the composition could be determined. On warming, the imide chloride is formed in the usual manner, but I am inclined to regard it as at least possible that a small proportion of the amide chloride distils over unchanged with the imide chloride, which would account for the composition of the iminoether and its behaviour towards acetic anhydride. This supposition would be capable of verification if the amide chloride could be isolated and made to react with sodium methoxide in accordance with the equation : Ph·CCl_o·NHMe + $2NaOMe = Ph \cdot C(OMe)_{2} \cdot NHMe + 2NaCl.$

The solid, supposed amide chloride, from 8.5 grams of benzmethylamide was separated by dissolving the product of reaction in dry benzene, precipitating with light petroleum, and drying for an hour in an exhausted desiccator; it was then redissolved in benzene and treated with a methyl-alcoholic solution of sodium methoxide. On distillation in a vacuum the chief fraction, which boiled at 86–88° under 11 mm. pressure, weighed 1.3 grams and gave C = 70.92; H = 7.42, $C_9H_{11}ON$ requiring C = 72.48; H = 7.4 and $C_{10}H_{15}O_2N$ requiring C = 66.2; H = 8.3 per cent. The composition of the product differs so little from that of the iminoether, prepared from distilled imide chloride, that no certain conclusions can be drawn regarding its probable constitution.

N-Methylbenziminoethyl ether, Ph·C(OEt):NMe, was not obtained in a pure state owing to lack of material. The boiling point of the crude compound lay between $103-108^{\circ}$ under 14 mm., and $214-217^{\circ}$ under the ordinary pressure. The percentage composition of the small amount which distilled at 215° was $C=72\cdot2$; $H=8\cdot0$; $N=7\cdot9$; the calculated values being $C=73\cdot6$; $H=7\cdot97$; $N=8\cdot6$ per cent.

The properties of the substance, however, left no doubt that the iminoether formed the major part of the product.

LANDER: SYNTHESIS OF IMINOETHERS.

III. N-Benzylbenziminoethers.

The imide chloride of benzbenzylamide, $Ph \cdot CCl:NCH_2Ph$, has been described by Pechmann and Heinze (Ber., 1897, 30, 1788) who assigned to it the boiling point 110° under 80 mm. pressure. According to these authors, this imide chloride is decomposed by aniline or methylaniline into benzonitrile and benzylaniline or benzylmethylaniline, thus:

$Ph \cdot CCl: N \cdot CH_2Ph + Ph \cdot NH_2 = Ph \cdot CN + Ph \cdot NHCH_2Ph, HCl.$

This anomalous behaviour proves, however, to be due to the instability of the imide chloride, which, on attempted distillation, splits almost completely into a mixture of benzonitrile and benzylchloride $Ph \cdot CCl:NCH_2Ph = Ph \cdot CN + CH_2PhCl$; at the same time a certain amount of the imide chloride passes over unchanged.* This is shown by a comparison of the results of iminoether synthesis with distilled and undistilled imide chloride respectively. Moreover, if the imide chloride is not distilled, the synthesis of the mixed phenylbenzylbenzenylamidine of Beckmann and Fellrath (Annalen, 1893, 273, 1) can be effected in the usual way.

Distillation of the Imide Chloride of Benzbenzylamide and Action of Sodium Ethoxide on the Distillate.-Ten grams each of phosphorus pentachloride and benzbenzylamide were mixed and made to react by gentle warming. After removing phosphorus oxychloride in a vacuum below 45°, the temperature of the bath was raised. With the bath at 180°, distillation began at 80° under 12 mm. pressure, and continued slowly, the temperature steadily rising until the distillation thermometer indicated 160°, the pressure throughout remaining constant. At this temperature the flask became filled with white fumes, and the operation was stopped. The distillate, a pale yellow, mobile liquid, represented about one-half of the reaction mixture; the residue was dark brown and tarry, and gave, on extraction with dilute sulphuric acid, a base which formed an insoluble hydriodide, and was probably an amidine, a considerable quantity of benzbenzylamide remaining un-The results of a second experiment confirmed these obserdissolved. vations.

The distillate, which gave a slightly turbid solution in light petroleum, was rendered distinctly alkaline by the addition of a solution of about 0.3 gram of sodium in ethyl alcohol. After washing with water and desiccation with potassium carbonate it was distilled, when the greater part passed over between $100-105^{\circ}$ under 30-40 mm. pressure.

^{*} A similar observation, made by Ley and Holzweissig, was published (*Ber.*, 1903, **36**, 19) after this paper had been handed in for publication.

The distillation then stopped and the second fraction boiling at 185° under 9 mm. pressure, was shown by its behaviour towards aqueous hydrochloric acid to be N-benzylbenziminoethyl ether (described later). The amount formed was small, but served to show that some imide chloride had distilled unchanged. The lower boiling fraction was redistilled between $183-187^{\circ}$ under the ordinary pressure, and on boiling for 6 hours with concentrated aqueous potassium hydroxide gave ammonia and benzoic acid, thus proving the presence of benzonitrile, and a neutral oil free from nitrogen and halogen, boiling at 183° (uncorr.) and possessing the characteristic odour of the benzyl alkyl ethers. The formation of benzyl ethyl ether points to the presence of benzyl chloride in the distillate.

Synthesis of Phenylbenzylbenzenylamidine, $Ph\cdot C(:NCH_2Ph)\cdot NHPh$, from the Imide Chloride of Benzbenzylamide.—After distilling phosphorus oxychloride under diminished pressure from the reaction product of equal weights of phosphorus pentachloride and benzbenzylamide, the syrupy residue was dissolved in light petroleum and one mol. of aniline was added. After some time, the petroleum was poured off and was found to contain no benzonitrile. The residual hydrochloride was extracted with dilute sulphuric acid, and the amidine liberated by adding sodium hydroxide. After two crystallisations from dilute alcohol the base melted at 99—100° and proved to be identical with Beckmann and Fellrath's product from the imide chloride of benzphenylamide and benzylamine (*loc. cit.*).

0.1403 gave 0.4322 CO_2 and 0.0815 H_2O . C = 84.01; H = 6.45. $C_{20}H_{18}N_2$ requires C = 83.9; H = 6.3 per cent.

Phenylmethylbenzylbenzenylamidine, $Ph \cdot C(:NCH_2Ph) \cdot NMePh$, was prepared by adding methylaniline (1 mol.) dissolved in benzene to a solution of the undistilled imide chloride of benzbenzylamide in the same solvent. A clear brown solution of the hydrochloride was thus obtained from which the base was separated by distilling off the solvent, extracting the residue with dilute sulphuric acid, and precipitating the clear solution with alkali. After three crystallisations, the base was obtained in colourless prisms melting constantly at $89-90^{\circ}$, and not 95° as given by Pechmann and Heinze (*loc. cit.*):

0.1164 gave 0.3578 CO₂ and 0.0706 H₂O. C = 83.83; H = 6.73. C₂₁H₂₀N₂ requires C = 84.0; H = 6.66 per cent.

This compound was also formed when the synthetic amidine, the formation of which has just been described, was methylated by boiling for 2—3 hours with excess of methyl iodide; when liberated from its hydriodide and crystallised from dilute alcohol, it melted at $89-90^{\circ}$, and did not depress the melting point of the preceding preparation

The correctness of the formula $Ph \cdot C(:NCH_2Ph) \cdot NHPh$, proposed by Pechmann for Beckmann and Fellrath's amidine, is thus confirmed.

N-Benzylbenziminoethyl ether, $Ph \cdot C(OEt): NCH_2Ph$, was prepared by mixing an alcoholic solution of sodium ethoxide and a light petroleum solution of the undistilled imide chloride in the same way as that previously described (Trans., 1902, 81, 593). On distilling the product under diminished pressure, the ether was obtained as a thick, colourless, odourless oil boiling at $186-188^{\circ}$ under 12 mm. pressure :

0.1430 gave 0.4200 CO₂ and 0.0934 H₂O. C = 80.1; H = 7.25.

0.1850 , 9.2 c.c. moist nitrogen at 12° and 766 mm. N = 5.93. C₁₆H₁₇ON requires C = 80.3 ; H = 7.1 ; N = 5.85 per cent.

The iminoether, which did not give a solid hydrochloride, was hydrolysed by aqueous mineral acids into ethyl benzoate and benzylamine, and, on condensation with aniline, gave Beckmann and Fellrath's amidine.

N-Benzylbenziminomethyl ether, $Ph \cdot C(OMe): NCH_2Ph$, prepared like the ethyl compound, boiled at $178-180^{\circ}$ under 11 mm. pressure, 19 grams of purified product being formed from 30 grams benzbenzylamide:

0.2086 gave 11.0 c.c. moist nitrogen at 15° and 752 mm. N = 6.1. C₁₅H₁₅ON requires N = 6.2 per cert.

The properties of the methyl compound resemble those of the ethyl homologue, and it gives the amidine melting at $99-100^{\circ}$ on condensation with aniline.

The Oxidation of the N-Benzylbenzimino Ethers by Atmospheric Oxygen.—The N-benzylbenzimino ethers are sharply distinguished from the allied aryl- and alkyl-compounds by the ease with which they are oxidised on exposure to air. In a few days, the liquid iminoethers deposit long, prismatic crystals which, after crystallisation from dilute alcohol, melt at $147-148^{\circ}$. The solid is soluble in cold potassium hydroxide, and is recovered unchanged by immediate acidification. After a time, the alkaline solution deposits leaflets of benzamide melting at 125° .

This behaviour and the analytical data leave no doubt that the solid is dibenzamide (m. p. 148°).

0.1344 gave 0.3685 CO_2 and 0.0612 H_2O . C = 74.8; H = 5.1.

0.1573 gave 8.9 c.c. moist nitrogen at 19° and 755 mm. N = 6.4.

 $C_{14}H_{11}O_2N$ requires C = 74.7; H = 4.9; N = 6.2 per cent.

The mechanism of the oxidation of the compounds $PhCOR:NCH_2Ph$ to $PhCO\cdot NH\cdot COPh$ cannot readily be explained in a satisfactory manner, and in consequence of the hydrolysis of the iminoethers by

329

acids and of dibenzamide by alkalis, it is not easy to find an alternative oxidising agent. Hydrogen peroxide and neutralised Caro's acid are apparently not suitable, and slightly alkaline potassium ferricyanide gives mainly unaltered iminoether and potassium benzoate.

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