

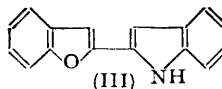
Oxygen Heterocycles. Part III. The Reactivity of Benzofuran and 2-Alkylbenzofurans.*

By M. BISAGNI, NG. PH. BUU-HOÏ, and R. ROYER.

[Reprint Order No. 6472.]

Benzofuran is shown to be more reactive than thionaphthen, and to undergo formylation in position 2; the same reaction occurs at position 3 with 2-substituted coumarones. Benzofuran itself was unstable under the conditions of Friedel-Crafts reactions, but its 2-substituted homologues were readily acylated at position 3. Several cases of steric hindrance were observed, and many new derivatives were prepared.

WHILST the relative reactivities benzene < thiophen < furan have been well established by numerous chemical investigations, and upheld by π -electron-density studies, little comparative experimental or theoretical work has been done with the binuclear sequence naphthalene-thionaphthen (I)-benzofuran (II). A study in this direction has now been undertaken. The reactions used included formylation by means of *N*-methylformanilide



(or dimethylformamide), and Friedel-Crafts acylation with acid chlorides in the presence of stannic chloride. The first of these reactions is known not to give an aldehyde from naphthalene, and gives only very poor yields of 3-formylthionaphthen (cf. Weston and Michaels, *J. Amer. Chem. Soc.*, 1950, **72**, 1422, who recorded a 9% yield; we confirmed this, and failed to improve it with dimethylformamide or *N*-methylformanilide).

Benzofuran has now been found to undergo formylation more easily than thionaphthen, and, unlike the latter, at position 2 (this aldehyde is known; Reichstein *et al.*, *Helv. Chim. Acta*, 1930, **13**, 1275; Normant, *Bull. Soc. chim. France*, 1946, **12**, 609). 2-Methyl- and 2-ethyl-benzofuran (prepared by Wolff-Kishner reduction of 2-formyl- and 2-acetyl-benzofuran) were formylated even more easily, giving excellent yields of 3-formyl-2-methyl- and 2-ethyl-2-formyl-benzofuran; the benzene ring is inert in this reaction, for 2:3-dimethyl- and 2-ethyl-3-methyl-benzofuran are not formylated. A 5-chlorine atom hinders formylation; and a 7-methoxy-group facilitates it.

The various formylbenzofurans investigated displayed the normal aldehyde properties (formation of hydrazones, semicarbazones, and oximes), but a 2-alkyl substituent caused steric hindrance, as shown by the increasing difficulty in Wolff-Kishner reduction of the following sequence: 2-formyl-, 3-formyl-2-methyl-, and 2-ethyl-3-formyl-benzofuran; also, the oxime of 2-ethyl-3-formylbenzofuran was readily dehydrated to 3-cyano-2-ethyl-coumarone, but this compound could not be hydrolysed further than to the amide (for similar observations in hydrolysis of amides, see Buu-Hoï and Cagniant, *Compt. rend.*, 1944, **219**, 455; *Rec. Trav. chim.*, 1946, **65**, 246). Further, 2-formyl- but not 2-ethyl-3-formyl-benzofuran gave a chalcone with acetophenone.

The relative reactivities in formylation are found also in Friedel-Crafts acylation. Benzofuran itself is almost wholly resinified by Lewis acids as mild as stannic chloride and phosphoric acid, but 2-alkylbenzofurans are readily acylated at position 3 by acid chlorides in the presence of stannic chloride. Again, 2:3-dialkyl derivatives were unreactive, a 5-chlorine atom hampered the acylation and a 7-methoxy-group favoured it. Propionyl and *n*-butyryl chloride gave similar results.

* Papers by Buu-Hoï, *J.*, 1952, 489, and Buu-Hoï and Demerseman, *J.*, 1952, 4699, are considered as Parts I and II of this series.

2-Acetylbenzofuran reacted normally with methylmagnesium iodide to give 2-2'-benzofurylpropan-2-ol, with phenylhydrazine to give a hydrazone which was readily converted by zinc chloride into 2-2'-benzofurylindole (III), and with isatin to give 2-2'-benzofurylcinchonic acid in excellent yield. 2-Acetyl-5-chloro- and 2-acetyl-7-methoxybenzofuran gave similar cinchoninic acids; and from the three acids the corresponding quinolines were readily prepared by thermal decarboxylation. With 3-acetyl-2-ethylbenzofuran and its 5-chloro- and 7-methoxy-derivatives, however, no Pfitzinger reaction took place, on account of steric hindrance; 2-acetyl-3-ethylthionaphthen is similarly inert (Buu-Hoï and Cagniant, *Ber.*, 1943, **76**, 1269). Steric hindrance would also account for the unusual stability of the hydrazone of 3-acetyl-2-ethylbenzofuran, and the consequent failure to convert it into the 2 : 3-diethyl compound by heating it with potassium hydroxide. It is worth mention that the methyl group of the acetyl radical in 3-acetyl-2-ethylbenzofuran is less subject to steric hindrance, and consequently a chalkone could be prepared with benzaldehyde, and 2-ethylbenzofuran-3-carboxylic acid was obtained by sodium hypobromite degradation.

The naphtho(2' : 1'-2 : 3)furan nucleus proved chemically similar to coumarone itself, except that its reactivity was less pronounced. Thus, the 5-ethyl derivative, prepared by Wolff-Kishner reduction of the acetyl compound, was formylated to 5-ethyl-4-formyl-naphtho(2' : 1'-2 : 3)furan (IV; R = H) and acylated to the 4-acetyl-5-ethyl analogue



(IV; R = Me), with moderate yields in both cases. Here again, no Pfitzinger reaction occurred with isatin and the ketone (IV; R = Me), whereas 5-acetylnaphtho(2' : 1'-2 : 3)furan readily gave the cinchoninic acid (V; R = CO₂H), which was decarboxylated to the quinoline (V; R = H).

During this work, Stoermer and Schaeffer's synthesis of 2-acylbenzofuran from ω -halogenated ketones and salicylaldehyde (*Ber.*, 1903, **36**, 2864) was more thoroughly investigated and it was found that the relatively low yields recorded were due to formation of chalkones. Thus, after reaction of chloroacetone with salicylaldehyde, substantial amounts of 2-2'-hydroxycinnamoylbenzofuran were isolated; and there were similar by-products in the reaction with 5-chloro- and 3-methoxy-salicylaldehyde.

EXPERIMENTAL

Formylation of Benzofuran.—Benzofuran was prepared in 29% yield by heating *o*-formylphenoxyacetic acid with acetic anhydride and sodium acetate for 3 hr. (Rössing, *Ber.*, 1884, **17**, 300); the yield was 15.2% when sodium acetate was omitted, and benzofuran-2-carboxylic acid, m. p. 191° (from water), was isolated as a by-product.

To a mixture of benzofuran (46 g.) and dimethylformamide (33 g.), phosphorus oxychloride (66 g.) was added in small portions; heat was evolved, and the mixture was then refluxed for 6–7 hr. with frequent shaking. After cooling, saturated aqueous sodium hydroxide (500 c.c.) was added, the mixture shaken for 15 min., the product taken up in ether, and the ethereal solution washed successively with dilute hydrochloric acid, dilute aqueous sodium carbonate, and water, then dried (Na₂SO₄). The residue from evaporation of the solvent was fractionated *in vacuo*, giving 40% of unchanged benzofuran and 37.7% of 2-formylcoumarone, b. p. 135°/18 mm., n_D^{25} 1.6337 [semicarbazone, m. p. 251°; phenylhydrazone, m. p. 136° (lit., m. p. 245–246° and 136–138° respectively)]. β -2-Benzofurylacrylophenone, prepared by adding 2 drops of 20% aqueous sodium hydroxide to a solution of 2-formylbenzofuran (1.7 g.) and acetophenone (1.7 g.) in warm ethanol, formed lemon-yellow needles, m. p. 92°, from methanol (Found : C, 81.9; H, 4.7. C₁₇H₁₂O₂ requires C, 82.2; H, 4.8%).

2-Methylbenzofuran.—A solution of 2-formylbenzofuran (21.5 g.) and 85% hydrazine hydrate (10 g.) in diethylene glycol (100 c.c.) was heated for a few minutes, potassium hydroxide (11.2 g.)

was added, and the mixture refluxed for 2 hr. with removal of both water and the product. The distillate was extracted with benzene, and the benzene layer washed with dilute hydrochloric acid, then with water, and dried (Na_2SO_4). Fractionation of the residue after evaporation of the solvent gave colourless 2-methylbenzofuran (5 g.), b. p. 189—191°.

3-Formyl-2-methylbenzofuran.—2-Methylbenzofuran (5 g.), dimethylformamide (3 g.), and phosphorus oxychloride (6.5 g.) were refluxed for 11 hr. and worked up in the usual way. The *aldehyde* (4.5 g.) formed pale yellow needles, m. p. 79° from light petroleum (b. p. 35—60°) (Found: C, 75.2; H, 5.2. $\text{C}_{10}\text{H}_8\text{O}_2$ requires C, 75.0; H, 5.0%). The *semicarbazone* crystallised as yellowish prisms, m. p. 243° (decomp. above 222°), from ethanol (Found: N, 19.0. $\text{C}_{11}\text{H}_{11}\text{O}_2\text{N}_3$ requires N, 19.3%).

2:3-Dimethylbenzofuran.—Prepared in 50% yield by Wolff-Kishner reduction of the foregoing aldehyde, this compound was a colourless oil, b. p. 100—101°/15 mm., n_D^{25} 1.5591 (Found: C, 82.2; H, 6.5. $\text{C}_{10}\text{H}_{10}\text{O}$ requires C, 82.1; H, 6.8%); it failed to react with dimethylformamide and phosphorus oxychloride, or with acetyl chloride in the presence of stannic chloride.

Stoermer-Schaeffer Synthesis of 2-Acetylbenzofuran.—In accordance with these authors, a 63% yield was obtained of 2-acetylcoumarone, b. p. 140—145°/15 mm., m. p. 75—76° (from methanol); 2-2'-hydroxycinnamoylbenzofuran, isolated as a by-product (from the alkaline liquors), crystallised as fine, pale yellow needles, m. p. 193° (decomp. above 177°), from benzene or ethanol, soluble in aqueous sodium hydroxide, and giving a blood red halochromy in sulphuric acid (Found: C, 77.0; H, 4.5. $\text{C}_{17}\text{H}_{12}\text{O}_3$ requires C, 77.3; H, 4.5%). The yield of this compound increased from 5 to 15% as the period of heating of chloroacetone with salicylaldehyde was lengthened from 3—4 hr. to 18 hr., or when a large excess of salicylaldehyde was used. 2-Acetylbenzofuran *hydrazone* formed yellow leaflets, m. p. 146°, from ethanol (Found: C, 68.8; H, 5.7; N, 15.8. $\text{C}_{10}\text{H}_{10}\text{ON}_2$ requires C, 68.9; H, 5.7; N, 16.0%); the *azine*, prepared from the *hydrazone* and 2-acetylbenzofuran, and isolated as a by-product in the Wolff-Kishner reduction of 2-acetylbenzofuran, formed yellow needles, m. p. 167° (Found: C, 75.7; H, 5.1; N, 8.6. $\text{C}_{20}\text{H}_{16}\text{O}_2\text{N}_2$ requires C, 75.9; H, 5.0; N, 8.8%).

2-Ethylbenzofuran.—A solution of 2-acetylbenzofuran (100 g.) and 85% hydrazine hydrate (100 g.) in diethylene glycol (250 c.c.) was brought to the boil, and, after cooling, treated with potassium hydroxide (90 g.), and the mixture was refluxed for 2 hr. with removal of water. After the usual treatment, 2-ethylbenzofuran (83 g., 91%) was obtained as a colourless oil, b. p. 211—212°, n_D^{25} 1.5522; Schreiner and Anderson (*J. Amer. Chem. Soc.*, 1939, 61, 2705) prepared this compound in another way.

2-2'-Benzofurylcinchoninic Acid.—A solution of 2-acetylbenzofuran (1.6 g.), isatin (1.5 g.), and potassium hydroxide (1.7 g.) in ethanol (10 c.c.) was refluxed for 8 hr. After addition of water and removal of neutral impurities with ether, the aqueous layer gave on acidification with acetic acid the *cinchoninic acid* (90%) which crystallised as pale yellow prisms, m. p. 285—286° (decomp. above 274°), from acetic acid (Found: C, 74.5; H, 3.7; N, 4.6. $\text{C}_{18}\text{H}_{11}\text{O}_3\text{N}$ requires C, 74.7; H, 3.8; N, 4.8%). 2-2'-Benzofurylquinoline, obtained by heating this acid above its m. p. and distilling the residue *in vacuo*, formed colourless needles, m. p. 128°, from ethanol (Found: C, 83.5; H, 4.6; N, 5.5. $\text{C}_{17}\text{H}_{11}\text{ON}$ requires C, 83.2; H, 4.4; N, 5.7%), giving a picrate (yellow needles, from ethanol), m. p. 227° (decomp. above 195°).

2-2'-Benzofurylindole (III).—A solution of 2-acetylbenzofuran (12 g.) and phenylhydrazine (10 g.) in ethanol was refluxed for 10 min. The oil formed on addition of water was taken up in benzene, and the crude solid phenylhydrazone heated with fused zinc chloride (20 g.) at 150—200° for 15 min. After cooling, 10% aqueous sodium hydroxide was added, and the *indole* taken up in benzene and purified by distillation *in vacuo* (b. p. 250—260°/15 mm.). It crystallised as colourless, sublimable prisms, m. p. 218°, from ethanol (Found: C, 82.8; H, 5.0; N, 5.8. $\text{C}_{16}\text{H}_{11}\text{ON}$ requires C, 82.4; H, 4.7; N, 6.0%).

2-2'-Benzofurylpropan-2-ol.—To a cooled ethereal solution of methylmagnesium iodide (prepared from 10 g. of methyl iodide and 2.2 g. of magnesium), 2-acetylbenzofuran (10 g., dissolved in ether) was added dropwise with stirring, and the mixture refluxed for 30 min. After cooling, an ice-cooled solution of ammonium chloride was added, the organic layer washed with water and dried (Na_2SO_4), the solvent evaporated, and the residue fractionated *in vacuo*. The alcohol was a pale yellow oil with a slight aniseed odour, b. p. 138°/15 mm., n_D^{25} 1.5783 (Found: C, 75.2; H, 6.6. $\text{C}_{11}\text{H}_{12}\text{O}_2$ requires C, 75.0; H, 6.8%).

2-Ethyl-3-formylbenzofuran.—2-Ethylbenzofuran (30 g.) and dimethylformamide (16.5 g.) were refluxed with phosphorus oxychloride (34.6 g.) for 11 hr., and the product worked up in the usual way. The *aldehyde* (23.5 g.) was a pale yellow oil, b. p. 148—150°/15 mm., n_D^{25} 1.5813

(Found : C, 75.5; H, 5.6. $C_{11}H_{10}O_2$ requires C, 75.8; H, 5.7%), giving a cherry-red halochromy in sulphuric acid. The *oxime* formed colourless prisms, m. p. 78°, from ligroin (Found : C, 70.0; H, 6.8; N, 7.5. $C_{11}H_{11}O_2N$ requires C, 69.8; H, 5.8; N, 7.3%).

3-Cyano-2-ethylbenzofuran.—A solution of the foregoing oxime (14 g.) in acetic anhydride (40 g.) was refluxed for 2 hr., and the product fractionated *in vacuo*; the *nitrile* (8.5 g.) was a pale yellow oil, b. p. 149—150°/18 mm., n_D^{25} 1.5596 (Found : C, 77.0; H, 5.3; N, 8.0. $C_{11}H_9ON$ requires C, 77.1; H, 5.3; N, 8.1%). A mixture of this nitrile (3 g.), sulphuric acid (5 c.c.), and water (7 c.c.) was refluxed for 3 hr. After cooling, water was added, and the solid precipitate which formed was recrystallised from water, giving *2-ethylbenzofuran-3-carboxamide* as colourless needles, m. p. 163—164° (Found : C, 69.6; H, 5.7; N, 7.1. $C_{11}H_{11}O_2N$ requires C, 69.8; H, 5.8; N, 7.4%); no acid was obtained, even on prolonged heating with potassium hydroxide in ethanol.

2-Ethyl-3-methylbenzofuran.—Wolff-Kishner-Huang-Minlon reduction of 2-ethyl-3-formylbenzofuran (10 g.) with hydrazine hydrate (10 g.) and potassium hydroxide (10 g.) in diethylene glycol gave only a 38% yield (3.5 g.) of this *compound*, as a colourless oil, b. p. 108—110°/15 mm., n_D^{25} 1.5611 (Found : C, 82.4; H, 7.7. $C_{11}H_{12}O$ requires C, 82.5; H, 7.5%). *2-Ethyl-3-formylbenzofuran hydrazone* was recovered unchanged (60% yield), b. p. 220—221°/14 mm., and formed colourless needles, m. p. 136°, from ethanol (Found : N, 14.7. $C_{11}H_{12}ON_2$ requires N, 14.8%).

3-Acetyl-2-ethylbenzofuran.—To a water-cooled solution of 2-ethylbenzofuran (29 g.) and acetyl chloride (16 g.) in dry carbon disulphide (200 c.c.), stannic chloride (52 g.) was added in small portions with stirring, and the mixture left for 3 hr. at room temperature, then poured into water. The organic layer was washed with water and dried (Na_2SO_4), the solvent evaporated, and the residue fractionated *in vacuo*; *3-acetyl-2-ethylbenzofuran* (30 g.; 80.6%) was a yellow oil, b. p. 165—166°/20 mm., n_D^{27} 1.5679 (Found : C, 76.5; H, 6.7. $C_{12}H_{12}O_2$ requires C, 76.6; H, 6.4%). The *oxime*, b. p. 194—195°/20 mm., formed needles, m. p. 81°, from ligroin (Found : C, 70.8; H, 6.4; N, 6.7. $C_{12}H_{13}O_2N$ requires C, 70.9; H, 6.4; N, 6.8%), and the *thiosemicarbazone* prisms, m. p. 148°, from ethanol (Found : C, 59.6; H, 5.7. $C_{13}H_{15}ON_3S$ requires C, 59.7; H, 5.7%).

Several attempts to reduce this ketone (10 g.) by hydrazine in the usual way led only to the *hydrazone* (8 g.), b. p. 225°/15 mm., prisms, m. p. 121° (from ligroin-cyclohexane) (Found : C, 72.1; H, 7.0; N, 13.7. $C_{12}H_{14}ON_2$ requires C, 71.2; H, 6.9; N, 13.8%).

3-Cinnamoyl-2-ethylbenzofuran.—To a solution of 3-acetyl-2-ethylbenzofuran (3 g.) and benzaldehyde (2 g.) in ethanol, 2 drops of 20% aqueous sodium hydroxide were added, and the mixture was kept at 50° for 15 min. An oil was precipitated, which became solid in the refrigerator, and on recrystallisation from aqueous ethanol gave yellow prisms which changed to a cloudy resin above 93° and a clear liquid at 140° (Found : C, 82.2; H, 5.6. $C_{13}H_{16}O_2$ requires C, 82.6; H, 5.7%); sulphuric acid gave an intense red halochromy.

2-Ethylbenzofuran-3-carboxylic Acid.—3-Acetyl-2-ethylbenzofuran (15 g.) was shaken for 2 hr. with aqueous sodium hypobromite (from 27 g. of sodium hydroxide and 13.6 c.c. of bromine in 160 c.c. of ice-cooled water). After addition of sodium hydrogen sulphite, the aqueous layer was acidified with hydrochloric acid, and the *acid* obtained was crystallised from aqueous ethanol, giving prisms (2.5 g.), m. p. 116° (Found : C, 69.8; H, 4.9. $C_{11}H_{10}O_3$ requires C, 69.4; H, 5.2%).

2-Ethyl-3-propionylbenzofuran.—To a solution of 2-ethylbenzofuran (10 g.) and propionyl chloride (6.5 g.) in carbon disulphide (75 c.c.), stannic chloride (18 g.) was added in small portions, and the mixture kept for 18 hr. at room temperature, then worked up in the usual way. The *ketone* obtained (10.3 g.) was a pale yellow oil, b. p. 163—164°/17 mm., n_D^{24} 1.5650 (Found : C, 77.0; H, 7.0. $C_{13}H_{14}O_2$ requires C, 77.2; H, 6.9%). The *oxime* formed needles, m. p. 93°, from ligroin (Found : C, 71.5; H, 6.8. $C_{13}H_{15}O_2N$ requires C, 71.8; H, 6.9%).

3-n-Butyryl-2-ethylbenzofuran.—Prepared as above from 2-ethylbenzofuran (10.5 g.) and *n*-butyryl chloride (8 g.) in 70% yield, this *ketone*, b. p. 178°/20 mm., formed colourless prisms, m. p. 63°, from ligroin (Found : C, 77.6; H, 7.4. $C_{14}H_{16}O_2$ requires C, 77.7; H, 7.4%).

5-Chloro-2-ethylbenzofuran.—2-Acetyl-5-chlorobenzofuran, b. p. 175°/12 mm., m. p. 103°, was prepared in 60% yield from 5-chlorosalicylaldehyde (110 g.) and chloroacetone (69 g.) according to Stoermer (*Annalen*, 1900, 312, 333); *5-chloro-2-(5-chloro-2-hydroxycinnamoyl)benzofuran*, obtained as a by-product, formed yellow needles, m. p. 222° (decomp. above 190°), from ligroin (Found : C, 61.5; H, 3.1. $C_{17}H_{10}O_3Cl_2$ requires C, 61.2; H, 3.0%). Reduction of 2-acetyl-5-chlorobenzofuran (33 g.) with hydrazine hydrate (30 g.) and potassium hydroxide (30 g.) in diethylene glycol (150 g.) gave *5-chloro-2-ethylbenzofuran* (25 g.), b. p. 128—129°/15

mm., n_D^{19} 1.5709, having a pronounced aniseed odour (Found: C, 66.1; H, 4.7. $C_{10}H_9OCl$ requires C, 66.4; H, 4.9%).

Formylation of 5-Chloro-2-ethylbenzofuran.—Reaction of 5 chloro-2-ethylbenzofuran (12 g.) with dimethylformamide (6 g.) and phosphorus oxychloride (13 g.), performed as for 2-ethylbenzofuran, gave a 6% yield of 5-chloro-2-formylbenzofuran, b. p. 175°/15 mm., characterised by its *oxime*, needles, m. p. 98° (from light petroleum) (Found: C, 59.3; H, 4.4; N, 6.2. $C_{11}H_{10}O_2NCl$ requires C, 59.0; H, 4.4; N, 6.2%).

2-(5-Chloro-2-benzofuryl)cinchoninic Acid.—Prepared as for the non-chlorinated compound, this *acid* formed from acetic acid yellow needles, m. p. >310° (Found: C, 66.5; H, 3.1. $C_{18}H_{16}O_2NCl$ requires C, 66.8; H, 3.1%); *2-(5-chloro-2-benzofuryl)quinoline* crystallised as cream-coloured leaflets, m. p. 189°, from aqueous ethanol (Found: N, 4.9. $C_{17}H_{16}ONCl$ requires N, 4.9%), and its picrate, m. p. 218—219° (decomp. above 190°), formed yellow needles from ethanol.

3-Acetyl-5-chloro-2-ethylbenzofuran.—Prepared from 5-chloro-2-ethylbenzofuran (9 g.), acetyl chloride (6 g.), and stannic chloride (16 g.) in carbon disulphide (80 c.c.) (3 hr. at room temperature), this *ketone* (3 g., 27%), b. p. 170°/13 mm., formed colourless needles, m. p. 59°, from light petroleum (Found: C, 64.8; H, 5.0. $C_{12}H_{11}O_2Cl$ requires C, 64.7; H, 4.9%); it gave a yellow halochromy with sulphuric acid.

2-Acetyl-7-methoxybenzofuran.—Prepared from *o*-vanillin (100 g.), chloroacetone (66.5 g.), and potassium hydroxide (38 g.) in ethanol, this *ketone* (58 g.), b. p. 176—180°/15 mm., formed colourless needles, m. p. 94°, from water, giving an orange halochromy with sulphuric acid (Found: C, 69.4; H, 5.3. $C_{11}H_{10}O_3$ requires C, 69.4; H, 5.2%). Reduction of this *ketone* (22 g.) with hydrazine hydrate (22 g.) and potassium hydroxide (20 g.) in diethylene glycol (100 c.c.) afforded *2-ethyl-7-methoxybenzofuran* (16.5 g., 81%) as a pale yellow oil, b. p. 136—137°/13 mm., n_D^{25} 1.5610 (Found: C, 74.8; H, 6.8. $C_{11}H_{12}O_2$ requires C, 75.0; H, 6.8%).

2-(7-Methoxy-2-benzofuryl)cinchoninic acid crystallised as pale yellow needles, m. p. 282°, from acetic acid (Found: C, 71.2; H, 4.0. $C_{18}H_{15}O_4N$ requires C, 71.5; H, 4.1%); *2-(7-methoxy-2-benzofuryl)quinoline* formed pale yellow leaflets, m. p. 148°, from ligroin (Found: C, 78.1; H, 4.8; N, 4.9. $C_{18}H_{15}O_2N$ requires C, 78.5; H, 4.7; N, 5.1%), and gave a picrate, golden-yellow needles, m. p. 220° (decomp. above 192°), from ethanol.

2-Ethyl-3-formyl-7-methoxybenzofuran.—This *aldehyde* (7 g., 76%), prepared from 2-ethyl-7-methoxybenzofuran (8 g.), dimethylformamide (4 g.), and phosphorus oxychloride (8.3 g.), formed colourless needles, m. p. 62°, from light petroleum (Found: C, 70.8; H, 6.0. $C_{12}H_{12}O_3$ requires C, 70.5; H, 5.8%) and gave a yellow halochromy with sulphuric acid and a *semicarbazone*, prisms (from aqueous ethanol), m. p. 174° (Found: N, 15.8. $C_{12}H_{12}O_3N_2$ requires N, 16.0%).

3-Acetyl-2-ethyl-7-methoxybenzofuran.—Prepared from 2-ethyl-7-methoxybenzofuran (3 g.), acetyl chloride (2 g.), and stannic chloride (6 g.) in carbon disulphide (50 c.c.) (15 min. at room temperature), this *ketone* (2 g., 54%) formed prisms, m. p. 57°, from light petroleum (Found: C, 71.6; H, 6.5. $C_{13}H_{14}O_3$ requires C, 71.5; H, 6.4%); it gave a yellow colour in sulphuric acid.

5-Ethyl-naphtho(2':1'-2:3)furan.—5-Acetylnaphtho(2':1'-2:3)furan, b. p. 245°/15 mm., m. p. 114° (from ligroin), was prepared according to Stoermer and Schaeffer (*loc. cit.*); the 2-hydroxy-1-naphthaldehyde used was obtained by Fosse's method (*Bull. Soc. chim. France*, 1901, 25, 373; Buu-Hoi, Hiong-Ki-Wei, and Royer, *Compt. rend.*, 1945, 220, 361). The *ketone* (29 g.) with hydrazine hydrate (15 g.) and potassium hydroxide (15 g.) in diethylene glycol (120 c.c.) afforded the *2-ethyl derivative* (22 g., 81.4%) as a pale yellow, viscous oil, b. p. 180—185°/15 mm., n_D^{25} 1.6388, giving an orange halochromy with sulphuric acid (Found: C, 85.8; H, 6.5. $C_{14}H_{12}O$ requires C, 85.7; H, 6.1%).

Pfitzinger reaction of the *ketone* (5 g.) with isatin (5.6 g.) afforded *2-(4-carboxy-2-quinolyl)-naphtho(2':1'-2:3)furan* (V; R = CO₂H) which was purified through its sparingly soluble sodium salt, and formed yellowish needles, m. p. >330°, from acetic acid (Found: C, 77.6; H, 3.6. $C_{22}H_{13}O_4N$ requires C, 77.9; H, 3.8%). The *2-2'-quinolyl derivative* (V; R = H) formed yellow prisms, m. p. 159°, from ligroin (Found: C, 85.5; H, 4.4; N, 4.4. $C_{21}H_{13}ON$ requires C, 85.4; H, 4.4; N, 4.7%), and gave a picrate, fine orange needles (from ethanol), decomp. >210°.

5-Ethyl-4-formylnaphtho(2':1'-2:3)furan (IV; R = H).—This *aldehyde* (4.6 g., 49.5%), prepared from the 2-ethyl compound (8 g.), dimethylformamide (3.1 g.), and phosphorus oxychloride (6.5 g.) in toluene (50 c.c.), formed cream-coloured needles, m. p. 79°, b. p. 240—245°/20 mm., from light petroleum (Found: C, 80.4; H, 5.4. $C_{15}H_{12}O_2$ requires C, 80.3; H, 5.3%), giving a greenish-yellow halochromy with sulphuric acid and a *semicarbazone*, fine, pale yellow

leaflets, m. p. 258° (decomp. >234°), from ethanol (Found: N, 14.8. $C_{16}H_{15}O_2N_3$ requires N, 14.9%).

4-Acetyl-5-ethylnaphtho(2':1'-2:3)furan (IV; R = Me).—This ketone (3 g., 32.6%), prepared from the 2-ethyl compound (8 g.), acetyl chloride (3.3 g.), and stannic chloride (11 g.) in carbon disulphide (100 c.c.), formed pale yellow prisms, m. p. 70°, b. p. 245—250°/15 mm., from light petroleum (Found: C, 80.6; H, 5.9. $C_{16}H_{14}O_2$ requires C, 80.6; H, 5.8%).

DEPARTMENT OF ORGANIC CHEMISTRY,
THE RADIUM INSTITUTE, UNIVERSITY OF PARIS.

[Received, June 1st, 1955.]
