[CONTRIBUTION FROM THE RADIUM INSTITUTE OF THE UNIVERSITY OF PARIS]

Reactivity of Some 6-Alkyl-2-naphthols and Their Ethers

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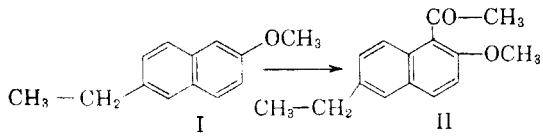
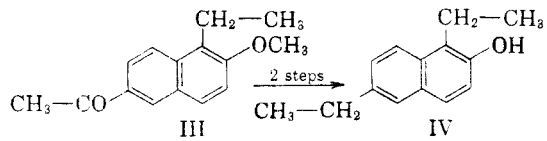
The Friedel-Crafts acetylation of 6-ethyl-2-methoxynaphthalene in nitrobenzene is shown to occur at position 1, proof being furnished by the identity of the naphthol prepared from the reaction product, with 1,6-diethyl-2-naphthol obtained from 6-acetyl-1-ethyl-2-methoxynaphthalene. Some other reactions of 6-alkyl-2-naphthols (Japp-Maitland condensation with phenylhydrazines) and their ethers (formylation) have been investigated.

It has been shown recently that the acyl group in the Friedel-Crafts acetylation of 1-alkyl-2-methoxynaphthalenes in nitrobenzene medium enters position 6.[1] It was of interest to investigate the orientation of similar acetylations in the case of 6-alkyl-2-methoxynaphthalenes. The starting material for this study was 6-ethyl-2-methoxynaphthalene (I), which reacted with acetyl chloride



I II

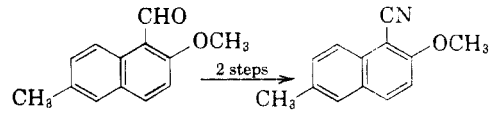
in nitrobenzene and in the presence of aluminum chloride to give a single ketone; this was 1-acetyl-6-ethyl-2-methoxynaphthalene (II), since in the course of a Wolff-Kishner reaction it underwent simultaneously reduction and demethylation, to give a small amount of 1,6-diethyl-2-naphthol (IV). The low yield in the last two operations is due to the fact that part of the ketone underwent alkaline hydrolysis to 6-ethyl-2-naphthol. The structure of naphthol IV was established by its identity with the demethylation product of 1,6-diethyl-2-methoxynaphthalene, prepared in excellent yields by Wolff-Kishner reduction of 6-acetyl-1-ethyl-2-methoxynaphthalene (III), this last ketone being obtained as a single product from the Friedel-Crafts acetylation of 1-ethyl-2-methoxynaphthalene.



III IV

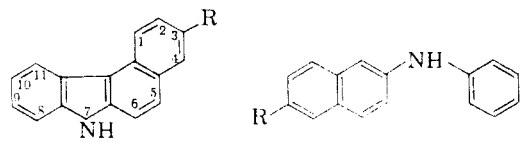
These results, together with others previously recorded,[1] establish positions 1 and 6 as the most reactive in the molecule of 2-methoxynaphthalene, while the main sites of Friedel-Crafts substitution in the molecule of 2-methylnaphthalene are positions 6 and 8;[2] it is also worth mentioning that 2-acetnaphthalide is acetylated in positions 6 and 8.[3]

The excellent yields of 2-methoxy-6-methyl-1-naphthaldehyde (V), obtained from the formylation of 2-methoxy-6-methylnaphthalene,[1] were



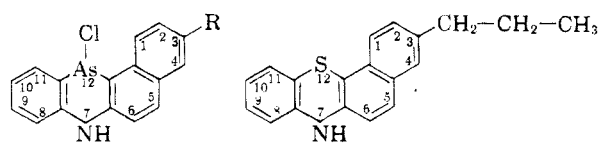
V VI

further proof of the high reactivity of position 1 in 6-alkyl-2-methoxynaphthalenes. Dehydration of the oxime of V afforded 2-methoxy-6-methyl-1-naphthonitrile (VI). Further reactions were performed with 6-alkyl-2-naphthols, to show the greater reactivity of position 1 than in the case of 2-naphthol itself. Thus, the Japp-Maitland condensation[4] of 6-alkyl-2-naphthols with phenylhydrazine gave good yields of 3-alkyl-7*H*-benzo[*c*]carbazoles (VII), in contrast with the low yields known with 2-naphthol; also, the Wieland-Rheinheimer condensation[5] of 6-alkyl-2-(phenylamino)-naphthalenes (VIII) with arsenic trichloride, to give the 3-alkyl-12-chloro-7,12-dihydrobenzo[*a*]-phenarsazines (IX), was easier than in the case of



VII VIII

2-*N*-phenylnaphthylamine. Similarly, 6-propyl-2-(phenylamino)naphthalene reacted readily with sulfur in the presence of iodine[6] to give an almost theoretical yield of 3-propyl-7*H*-benzo[*c*]pheno-



IX X

thiazine (X); this compound is of practical interest in view of its pronounced antioxidant properties and its ready solubility in fats.

(1) N. P. Buu-Hoï and D. Lavit, *J. Org. Chem.*, **22**, 912 (1957).

(2) G. A. R. Kon and W. T. Weller, *J. Chem. Soc.*, 792 (1939).

(3) N. Leonard and A. M. Hyson, *J. Am. Chem. Soc.*, **71**, 1392 (1949).

(4) F. R. Japp and W. Maitland, *J. Chem. Soc.*, **83**, 267 (1903).

(5) H. Wieland and W. Rheinheimer, *Ann.*, **423**, 1 (1921).

(6) E. Knoevenagel, *J. prakt. Chem.*, **89**, 15 (1914).

In the course of this work, it was found that 6-acetyl-1-ethyl-2-methoxynaphthalene (III) readily undergoes a Pfitzinger reaction with isatin to give 2-(1-ethyl-2-methoxy-6-naphthyl)cinchoninic acid; this gave on thermal decarboxylation, 2-(1-ethyl-2-methoxy-6-naphthyl)quinoline.

EXPERIMENTAL

1-Acetyl-6-ethyl-2-methoxynaphthalene (II). To a water-cooled, well stirred solution of 50 g. of 6-ethyl-2-methoxynaphthalene and 23.2 g. of acetyl chloride in 500 ml. of nitrobenzene, 39.5 g. of finely powdered aluminum chloride was added in small portions, and the mixture left overnight at room temperature. After decomposition with dilute hydrochloric acid, the nitrobenzene was removed by steam distillation, and the reaction product taken up in benzene. The benzene solution was then washed with water and dried over sodium sulfate, the solvent was removed, and the residue was vacuum-distilled to yield 45 g. (73%) of a ketone, b.p. 207°/20 mm., crystallizing from petroleum ether in lustrous colorless leaflets, m.p. 70°; no isomeric ketone was found in the mother liquors.

Anal. Calcd. for $C_{15}H_{16}O_2$: C, 78.9; H, 7.1. Found: C, 78.9; H, 7.3.

1-Ethyl-2-methoxynaphthalene. A solution of 64.7 g. of 1-acetyl-2-methoxynaphthalene, 32 g. of 95% hydrazine hydrate, and 30 g. of potassium hydroxide in 250 ml. of diethylene glycol was refluxed for 2.5 hr. with removal of water; after cooling, water was added, the impurities extracted in benzene, and the aqueous layer acidified with hydrochloric acid. The precipitate obtained was taken up in chloroform, the chloroform solution was washed with water and dried over sodium sulfate, the solvent was removed, and the residue was vacuum-distilled to yield 32 g. (58%) of 1-ethyl-2-naphthol, m.p. 105°, b.p. 184–185°/17 mm. This naphthol was methylated with methyl sulfate (27 g.) and potassium hydroxide (11 g.), to give 29.4 g. of 1-ethyl-2-methoxynaphthalene, b.p. 160°/20 mm., which solidified to colorless needles, m.p. 47°.

Anal. Calcd. for $C_{15}H_{14}O$: C, 83.8; H, 7.6. Found: C, 84.0; H, 7.5.

The preparation of 1-ethyl-2-naphthol was found much more convenient by this method than by those reported in the literature,[7] as 1-acetyl-2-methoxynaphthalene could be readily obtained by Friedel-Crafts acetylation of neroline, along with some of the 6-acetyl isomer; during the Kishner-Wolff reaction, this last ketone is reduced with no significant demethylation, and the 6-ethyl-2-methoxynaphthalene thus formed is easily eliminated by the benzene extraction.

6-Acetyl-1-ethyl-2-methoxynaphthalene (III). A solution of 27 g. of 1-ethyl-2-methoxynaphthalene and 12.5 g. of acetyl chloride in 100 ml. of nitrobenzene was treated with 21.3 g. of aluminum chloride in the usual way to yield 25 g. (75%) of a ketone, b.p. 215–216°/15 mm., crystallizing from ethanol in long colorless needles, m.p. 88°; here again, no isomer was found in the mother liquors.

Anal. Calcd. for $C_{15}H_{16}O_2$: C, 78.9; H, 7.1. Found: C, 78.8; H, 7.1.

2-(1-Ethyl-2-methoxy-6-naphthyl)cinchoninic acid. A solution of 2 g. of the foregoing ketone, 1.4 g. of isatin, and 1.5 g. of potassium hydroxide in 20 ml. of ethanol was gently refluxed for 24 hr., the ethanol was distilled off in a vacuum, and the residue treated with water; after ether-extraction of the neutral impurities, the aqueous layer was acidified with acetic acid, and the precipitate was recrystallized from ethanol, giving 2.5 g. (80%) of fine yellowish needles, m.p. 248°.

Anal. Calcd. for $C_{23}H_{19}NO_3$: C, 77.3; H, 5.4. Found: C, 77.0; H, 5.3.

(7) K. Fries and H. Engel, *Ann.*, **439**, 232 (1924).

2-(1-Ethyl-2-methoxy-6-naphthyl)quinoline, prepared by heating the foregoing cinchoninic acid above its melting point, and purified by vacuum-distillation, crystallized from ethanol in shiny yellowish leaflets, m.p. 148°.

Anal. Calcd. for $C_{22}H_{19}NO$: C, 84.3; H, 6.1. Found: C, 84.2; H, 6.2.

The picrate of this base crystallized from benzene in fine orange-yellow prisms, m.p. 235°.

1,6-Diethyl-2-naphthol (IV). 1,6-Diethyl-2-methoxynaphthalene was prepared by reduction of 20 g. of ketone III with 19 g. of 95% hydrazine hydrate and 16 g. of potassium hydroxide in 120 ml. of diethyl glycol. The yield was 14.5 g. (77%) of a pale yellow oil, b.p. 183°/18 mm., n_D^{25} 1.6100.

Anal. Calcd. for $C_{15}H_{18}O$: C, 88.2; H, 4.0. Found: C, 88.0; H, 4.2.

A mixture of 13 g. of this ether and 39 g. of redistilled pyridine hydrochloride was refluxed for 1 hr.; on cooling, water was added, and the demethylation product was taken up in chloroform. The chloroform solution was washed with dilute hydrochloric acid, then with water, dried over sodium sulfate, the solvent removed, and the residue was vacuum-fractionated to yield 9.5 g. of 1,6-diethyl-2-naphthol, b.p. 189–191°/20 mm., crystallizing from petroleum ether in shiny colorless needles, m.p. 75°.

Anal. Calcd. for $C_{14}H_{16}O$: C, 84.0; H, 8.1. Found: C, 83.7; H, 8.4.

The same product was obtained, in poorer yield (10%) in the reduction of 1-acetyl-6-ethyl-2-methoxynaphthalene (accompanied by demethylation) together with some 6-ethyl-2-naphthol (m.p. 98°).

2-Methoxy-6-methyl-1-naphthaldehyde (V). Fifty grams of the methyl ether of 6-methyl-2-naphthol,[8] 50.5 g. of *N*-methylformanilide, and 60 g. of phosphorus oxychloride was refluxed for 5 hr. on a water bath; after cooling, a concentrated aqueous solution of sodium acetate was added, and the mixture refluxed for 30 min. more. The reaction product was taken up in benzene, washed with dilute hydrochloric acid, then with water, dried over sodium sulfate, the solvent removed, and the residue vacuum-fractionated. The yield was 50 g. (86%) of an aldehyde, b.p. 228–229°/30 mm., crystallizing from petroleum ether in shiny colorless leaflets, m.p. 72°.

Anal. Calcd. for $C_{13}H_{12}O_2$: C, 78.0; H, 6.0. Found: C, 77.9; H, 6.0.

The corresponding semicarbazone crystallized from ethanol in shiny colorless needles, m.p. 244°. The *oxime* crystallized from ethanol in shiny colorless prisms, m.p. 168°.

Anal. Calcd. for $C_{13}H_{13}NO_2$: N, 6.5. Found: N, 6.4.

2-Methoxy-6-methyl-1-naphthonitrile (VI). Dehydration of 2.6 g. of the foregoing oxime was effected by shaking its ether solution with 3 g. of finely powdered phosphorus pentachloride; the ether layer was decanted, washed with aqueous sodium carbonate, then with water, and dried over sodium sulfate. The residue from evaporation of the solvent was recrystallized from cyclohexane, giving 1.9 g. (80%) of silky colorless needles, m.p. 100°.

Anal. Calcd. for $C_{13}H_{11}NO$: C, 79.2; H, 5.6. Found: C, 79.0; H, 5.5.

3-Propyl-7H-benzo[c]carbazole (VII; R = *n*-C_3H_7). A mixture of 4 g. of 6-propyl-2-naphthol, 4 g. of phenylhydrazine, and 4 g. of phenylhydrazine hydrochloride was cautiously refluxed for 1 hr.; after cooling, dilute aqueous sodium hydroxide was added, and the reaction product taken up in toluene. The toluene layer was washed with water and dried over sodium sulfate, the solvent was removed, and the residue vacuum-fractionated. The portion boiling at 280–305°/17 mm. (4 g., 72%) was recrystallized from cyclohexane, giving lustrous colorless leaflets, m.p. 127°. This substance crystallized with solvent, which was eliminated only at 115°.

(8) K. Dziewonski, J. Schoenowna, and E. Waldmann, *Ber.*, **58**, 1211 (1925).

Anal. Calcd. for $C_{19}H_{17}N$: C, 88.0; H, 6.6. Found: C, 88.2; H, 6.9.

This carbazole gave with tetrachlorophthalic anhydride an orange addition-product, crystallizing from acetic acid in fine orange needles; with picric acid, a picrate was formed, which crystallized from ethanol in fine brown red needles, m.p. 162°.

3-Butyl-7H-benzo[c]carbazole (VII; R = *n*-C_4H_9). Similarly prepared from 4 g. of 6-butyl-2-naphthol, this carbazole (3.5 g., 64%) crystallized from cyclohexane in lustrous colorless leaflets, m.p. 127°; the crystals were solvated, and the solvent was given off above 115°.

Anal. Calcd. for $C_{20}H_{19}N$: C, 87.9; H, 7.0. Found: C, 88.1; H, 7.0.

The corresponding picrate crystallized from ethanol in brown red needles, m.p. 168–169°; the addition-compound with tetrachlorophthalic anhydride crystallized from acetic acid in shiny orange prisms, m.p. 165–166°.

3-Propyl-12-chloro-7,12-dihydrobenzo[a]phenarsazine (IX; R = *n*-C_3H_7). 6-Propyl-2-(phenylamino)naphthalene (VIII; R = *n*-C_3H_7), previously described as a viscous oil,[9] was now obtained as a solid, m.p. 75°. A solution of 2.6 g. of this diarylamine in 5 ml. of *o*-dichlorobenzene was gently heated with 1.1 g. of arsenic trichloride until a vigorous reaction set up, then refluxed for 3 min.; cyclohexane was then added, and the solid obtained in 85% yield was filtered off and recrystallized from toluene, giving shiny deep yellow leaflets, m.p. 217–218°.

Anal. Calcd. for $C_{19}H_{17}AsClN$: C, 61.7; H, 3.8. Found: C, 61.4; H, 3.6.

3-Methyl-10-phenyl-12-chloro-7,12-dihydrobenzo[a]phenarsazine. 6-Methyl-2-(p-xenylamino)naphthalene was prepared by heating for 24 hr. a mixture of 3 g. of 6-methyl-2-naphthol, 4 g. of *p*-aminobiphenyl, and 0.1 g. of iodine;[10] the reaction product was taken up in benzene, the benzene solution washed with aqueous sodium hydroxide, then with water, dried over sodium sulfate, the solvent removed, and the residue recrystallized from ethanol, giving shiny colorless needles, m.p. 170°. The yield was 1.6 g. (27.5%).

Anal. Calcd. for $C_{23}H_{19}N$: C, 89.3; H, 6.2. Found: C, 89.2; H, 6.2.

Condensation of this amine (3.1 g.) with arsenic trichloride (1.1 g.) in *o*-dichlorobenzene was almost instantaneous, and gave a 90% yield of the phenarsazine, which crystallized from *o*-dichlorobenzene in shiny deep yellow prisms, melting with decomposition at 268°, and giving a deep blue coloration in sulfuric acid.

Anal. Calcd. for $C_{23}H_{17}AsClN$: C, 66.1; H, 3.4. Found: C, 65.8; H, 3.1.

3-Propyl-7H-benzo[c]phenothiazine (X). A mixture of 2.6 g. of 6-propyl-2-(phenylamino)naphthalene and 0.64 g. of sulfur was heated with 0.02 g. of iodine until a vigorous reaction set up, then kept at 150–160° for 2 min.; the reaction product gave on recrystallization from cyclohexane, 2.1 g. (72%) of pale yellow needles, m.p. 143–144°, giving a deep blue coloration in sulfuric acid.

Anal. Calcd. for $C_{19}H_{17}NS$: C, 78.3; H, 5.9. Found: C, 78.2; H, 6.2.

6-Butyl-2-(phenylamino)naphthalene (VIII; R = *n*-C_4H_9). This amine, prepared in the usual way from 3 g. of 6-butyl-2-naphthol, 2 g. of aniline, and 0.05 g. of iodine, boiled at 277–279°/20 mm., and crystallized from petroleum ether in shiny needles, m.p. 60°. Yield: 2 g. (48%).

Anal. Calcd. for $C_{20}H_{21}N$: C, 87.2; H, 7.7. Found: C, 87.1; H, 8.0.

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(9) N. P. Buu-Hoï, R. Royer, B. Eckert, and P. Jacquignon, *J. Chem. Soc.*, 4867 (1952).

(10) See N. P. Buu-Hoï, *J. Chem. Soc.*, 4346 (1952).

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Preparation of Vinylphenols and Isopropenylphenols

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Directions for the preparation of five alkenylphenols are reported.

Five alkenylphenols were prepared for evaluation as monomers—*o*-vinylphenol, *m*-vinylphenol, *p*-vinylphenol, *m*-isopropenylphenol, and *p*-isopropenylphenol. Of these alkenylphenols, *o*-vinylphenol and *p*-vinylphenol are the most accessible. Five preparative methods were employed: (*a*) decarboxylation of *o*-coumaric acid for *o*-vinylphenol; (*b*) dehydrogenation of *m*- and *p*-ethylphenols for *m*- and *p*-vinylphenols, dehydrogenation of *m*- and *p*-isopropylphenols for *m*- and *p*-isopropenylphenols; (*c*) hydrogenation of *p*-acetoxyacetophenone followed by dehydration-hydrolysis for *p*-vinylphenol; (*d*) cracking of 2,2-bis(*p*-hydroxyphenyl)propane and 2,2-bis(*p*-acetoxyphenyl) propane for *p*-isopropenylphenol; (*e*) depolymerization of poly-*p*-isopropenylphenol for *p*-isopropenylphenol.

o-Vinylphenol has usually been prepared by the decarboxylation of *o*-coumaric acid.[1-7] It has also been prepared from salicylaldehyde *via* the Grignard reaction[8] and by the pyrolysis of 2,4-dimethyl-1,3-benzodioxane.[9] Our starting material was *o*-coumaric acid. We confirmed the findings of

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(2) K. Auwers, *Ann.*, **413**, 253 (1917).
(3) H. Kunz-Krause, *Arch. Pharm.*, **236**, 542 (1898); *Chem. Zentr.*, II, 973 (1898).
(4) H. Kunz-Krause and P. Manicke, *Arch. Pharm.*, **267**, 555 (1929).
(5) C. S. Marvel and N. S. Rao, *J. Poly. Sci.*, **4**, 703 (1949).
(6) A. R. Bader, *J. Am. Chem. Soc.*, **77**, 4155 (1955).
(7) W. J. Dale and H. E. Hennis, Atlantic City A.C.S. Meeting, 1956.
(8) P. Hoering and F. Baum, Ger. patent **208,886** (1907).
(9) E. Adler, H. Euler, and G. Gie, *Arkiv. Kemi, Mineral., Geol.*, **16A**, No. 12, 1 (1943).