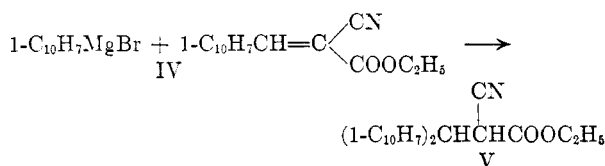


V, was obtained. Since the latter could be hydrolyzed to the corresponding malonic acid in 93% yield a distinct improvement in the synthesis of hexahelicene^{3c} has been attained.



EXPERIMENTAL

Diethyl 1-naphthylidenemalonate, II. In a flask fitted with a small packed column and a phase-separating head were placed 157 g. of 1-naphthaldehyde, 160 g. of diethyl malonate, 3 g. of benzoic acid, and 500 ml. of benzene. At reflux 5 ml. of piperidine was added. After 11 hr., during which four 2-g. additions of piperidine were made, slightly more than the theoretical amount of water had been collected. On distillation⁶ there was obtained 252 g. (85%) of II, b.p. 187–197° at 1.5–2.0 mm.

Diethyl phenyl-1-naphthylmethylmalonate, III. To a solution of 1-naphthylmagnesium bromide freshly prepared from 21 g. (0.1 mole) of 1-bromonaphthalene was added slowly with cooling 21 g. (0.085 mole) of diethyl benzylidenemalonate⁸ in 50 ml. of ether and the mixture was then stirred at room temperature for 6 hr. After treatment with saturated ammonium chloride solution and removal of ether from the washed and dried ether layer, there was obtained a crude solid mass which was heated with Skellysolve B (petroleum ether, b.p. 60–70°) and cooled. Filtration yielded 26.7 g. (84%) of III, m.p. 96–99°, good enough for further work. A sample recrystallized from absolute alcohol several times melted at 99.5–101.5°.⁷

When a solution of 21.5 g. of II in 50 ml. of ether was added to a solution of phenylmagnesium bromide freshly prepared from 17 g. of bromobenzene an insoluble complex separated. After stirring at room temperature for 6 hr., the reaction mixture was treated as above to yield 6.0 g. (22%)

(6) C. F. H. Allen and F. W. Spangler, *Org. Syntheses*, 25, 42 (1945).

(7) G. A. Holmberg, *Acta Acad. Aboensis Math. et Phys.*, 16, 138 (1948) gives the m.p. as 98–99°.

of III, m.p. 98–100°. In addition some biphenyl and a large quantity of tar were obtained.

Diethyl di-1-naphthylmethylmalonate. To a stirred mixture of 0.1 mole of freshly prepared magnesium bromide and 15 g. (0.05 mole) of II in ether was added 140 ml. of 0.5N (0.07 mole) 1-naphthylmagnesium bromide. After refluxing for 2 hr. the reaction mixture was treated with ammonium chloride solution and worked up as usual to yield 8.0 g. (38%) of III.⁵

To 3.0 g. (0.01 mole) of II in 20 ml. of dry ether was added under nitrogen 200 ml. of 0.1N di-1-naphthylmagnesium solution and 250 ml. of dry benzene. The mixture was heated and the ether distilled. After 40 hr. of refluxing, the mixture was decomposed by treating with ammonium chloride solution and worked up to yield 2.9 g. (97%) of II.

Ethyl 1-naphthylidenecyanoacetate, IV. A mixture of 100 g. of 1-naphthaldehyde, 74 g. of ethyl cyanoacetate, 6 g. of piperidine, 5 g. of benzoic acid, and 700 ml. of benzene was refluxed into a phase-separating head. After 1 hr. the theoretical amount of water had been collected. After the usual workup there was obtained 149 g. (92.8%) of crude IV, b.p. 180–195° at 1 mm. Recrystallization from alcohol afforded 142.6 g. (88.8%) of IV, m.p. 80.0–81.4°. The analytical sample melted at 81.0–81.4°.

Anal. Calcd. for C₁₈H₁₃O₂N: N, 5.6. Found: N, 5.3.

Ethyl di-1-naphthylmethylcyanoacetate, V. To the Grignard reagent prepared from 20.7 g. of 1-bromonaphthalene in ether-benzene and cooled to 0–5° was added 12.5 g. of IV in ether-benzene. After coming to room temperature the mixture was heated at reflux for 12 hr. and then poured into dilute hydrochloric acid. After the usual treatment 17.7 g. (94%) of V was isolated as a colorless solid, m.p. 189.8–191.0°, by crystallization from ethanol.

Anal. Calcd. for C₂₈H₂₁NO₂: C, 82.3; H, 5.6; N, 3.7. Found: C, 82.3; H, 5.6; N, 3.7.

Di-1-naphthylmethylmalonic acid. A mixture of 3.9 g. of V and 200 ml. of 50% aqueous alcoholic potassium hydroxide was refluxed for 31 hr., cooled, and poured into water. This aqueous solution was then poured into excess hydrochloric acid. The solid was collected and recrystallized from alcohol to yield 3.5 g. (92%) of the desired malonic acid,^{8c} m.p. 196° dec. Decarboxylation afforded the known 2,2-di-1-naphthylpropionic acid,^{8c} m.p. 248°.

COLUMBUS 10, OHIO

(8) Analyses by Galbraith Microanalytical Laboratories, Knoxville, Tenn.

[CONTRIBUTION FROM THE MCPHERSON CHEMICAL LABORATORY OF THE OHIO STATE UNIVERSITY]

Syntheses of 1'-Methyl- and 4'-Methyl-1,2-benzanthracenes¹

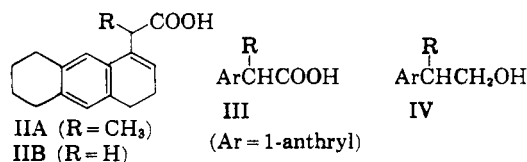
MELVIN S. NEWMAN AND SEI OTSUKA

Received January 31, 1958

The syntheses of 1'-methyl- and 4'-methyl-1,2-benzanthracene are described.

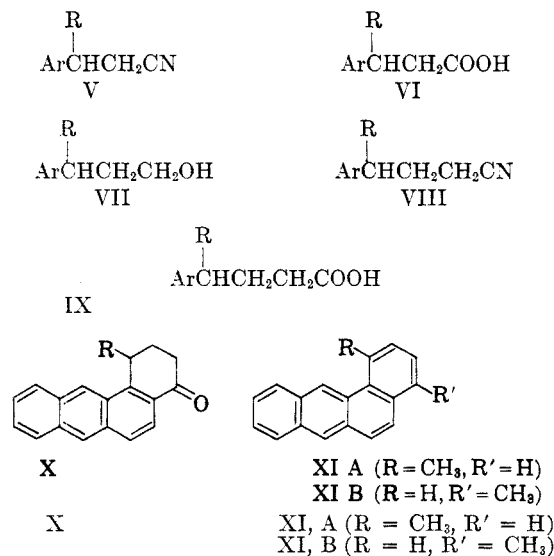
In a previous paper, the reasons for synthesizing relatively large amounts of all of the monomethyl-1,2-benzanthracenes were outlined and the syntheses of all but 1'-methyl- and 4'-methyl-1,2-benzanthracene were described.² In this paper are

described syntheses for the latter two compounds as outlined in the chart. More than 10 g. of each was made and is available for research workers.



(1) The work herein reported was supported by a grant, C-2484, from the U. S. Public Health Service to whom grateful acknowledgment is made.

(2) M. S. Newman and R. Gaertner, *J. Am. Chem. Soc.*, 72, 264 (1950).

EXPERIMENTAL³

2-(3,4,5,6,7,8-Hexahydro-1-anthryl)propionic acid, IIA, and 3,4,5,6,7,8-Hexahydro-1-anthrylacetic acid, IIB. 1-Keto-1,2,3,4,5,6,7,8-octahydroanthracene,⁴ I, was condensed with methyl α -bromopropionate as described⁵ to yield crude hydroxyester which was dehydrated by heating with a trace of iodine. The distilled unsaturated ester thus prepared was saponified and the resulting acid, IIA, was obtained in about 70% yield in sufficient purity to proceed. A pure sample of IIA formed crystals, m.p. 139–140°, on recrystallization from isopropyl ether.

Anal. Calcd. for C₁₇H₂₀O₂: C, 79.7; H, 7.9. Found:⁶ C, 79.4; H, 8.0.

In a similar way, methyl 3,4,5,6,7,8-hexahydro-1-anthrylacetate, b.p. 172–181° at 1.5 mm., was obtained in 85% yield from I by the Reformatsky reaction⁶ followed by dehydration. The methyl ester thus obtained was submitted to dehydrogenation as described below.

2-(1-Anthryl)propionic acid, IIIA, and 1-anthrylacetic acid, IIIB. The crude acid, IIA, described above, was converted almost quantitatively into methyl ester, b.p. 168–178° at 0.05 mm. by esterification with methanolic hydrogen chloride. After heating 27.0 g. of this ester with 0.27 g. of 20% palladium-on-charcoal⁷ in 13 g. of pure diphenyl ether at 260 to 305° for two hours (theoretical hydrogen evolved) the reaction mixture was saponified with alcoholic potassium hydroxide. The acidic portion of the product, on crystallization from benzene, afforded IIIA as pale yellow prisms, m.p. 169–171°, in 60% yield based on starting acid IIA. Several recrystallizations from benzene afforded pure IIIA, m.p. 171.0–172.5°.

Anal. Calcd. for C₁₇H₁₄O₂: C, 81.6; H, 5.6. Found: C, 81.7; H, 5.5.

In a similar way IIIB, m.p. 168–170°, was obtained in 70% yield from IIB. Pure IIIB, m.p. 170.0–171.2°, was obtained by crystallization from benzene.

Anal. Calcd. for C₁₆H₁₂O₂: C, 81.3; H, 5.1. Found: C, 81.4; H, 5.4.

3-(1-Anthryl)butyronitrile, VA, and 3-(1-anthryl)propionitrile, VB. Either the ethyl ester, b.p. 192–195° at 2 mm., of III or the methyl ester was reduced by lithium aluminum

hydride in ether at room temperature in almost quantitative yield to 2-(1-anthryl)propanol, IVA, m.p. 89–92°. The analytical sample, m.p. 93–94°, was prepared by crystallization from isopropyl ether.

Anal. Calcd. for C₁₇H₁₆O: C, 86.4; H, 6.8. Found: C, 86.4; H, 6.8.

The alcohol, IVA (23.6 g.), was treated in dry pyridine at 5–15° with a small excess of methanesulfonyl chloride to yield the methanesulfonate, a viscous oil, which was dissolved in a small amount of dry dimethylformamide and treated with a threefold excess of sodium cyanide, partly dissolved and suspended in 150 ml. of dimethylformamide. After heating at 40–60° for 3 hr. the organic product was isolated by extraction with ether-benzene and purified by passing a benzene solution through a short column of alumina. After concentration of the eluate and dilution with Skellysolve F (petroleum ether, b.p. 35–40°) the nitrile, VA, was obtained in 85% yield as crystals, m.p. 99–103°. Recrystallization from benzene-Skellysolve F and from isopropyl ether yield a pure sample, m.p. 105–106°, with little loss.

Anal. Calcd. for C₁₈H₁₅N: C, 88.1; H, 6.2; N, 5.7. Found: C, 88.3; H, 6.2; N, 5.7.

In a similar way, the methyl ester of IIIB was reduced to crude alcohol, IVB, m.p. 80–83°, methanesulfonylated, and converted to nitrile, VB, m.p. 125–128°, in 80% yield based on IIIB. A pure sample of VB melted at 128.3–129.1°.

Anal. Calcd. for C₁₇H₁₅N: C, 88.3; H, 5.7; N, 6.1. Found: C, 88.4; H, 5.7; N, 6.2.

3-(1-Anthryl)butyric acid, VIA, and 3-(1-anthryl)propionic acid, VIB. A solution of 23.1 g. of VA and 8.4 g. of potassium hydroxide in 150 ml. of ethylene glycol was heated from 160° to 200° during 5 hours (under nitrogen) to yield 18.5 g. (70%) of VIA, m.p. 152–156°. A sample recrystallized 3 times from benzene melted at 156–158°.

Anal. Calcd. for C₁₈H₁₆O₂: C, 81.8; H, 6.1. Found: C, 81.6; H, 6.2.

In a similar way, except that the hydrolysis was effected at 150–165°, VB was converted into VIB in about 70% yield. Undoubtedly, better conditions for hydrolysis could be worked out. The pure sample of VIB, obtained by crystallization from acetone and acetone-ether, melted at 197.5–198.5°.

Anal. Calcd. for C₁₇H₁₄O₂: C, 81.6; H, 5.6. Found: C, 81.6; H, 5.8.

4-(1-Anthryl)pentanonitrile, VIIIA, and 4-(1-anthryl)butyronitrile, VIIIB. The crude alcohol, VIIA, obtained by the lithium aluminum hydride reduction of VIA did not crystallize and was converted *via* the methanesulfonate to the nitrile, VIIIA, as described above for VA, in 60% over-all yield from VIA. As the nitrile VIIIA did not crystallize, the 2,4,7-trinitrofluorenone derivative,⁸ m.p. 159–160°, after preparation in and crystallization from acetic acid, was made.

Anal. Calcd. for C₂₂H₂₀O₇N₄: C, 66.9; H, 3.9; N, 9.8. Found: C, 66.9; H, 3.9; N, 9.8.

On reduction of the methyl ester of VIB with lithium aluminum hydride, the alcohol, VIIB, was obtained crystalline in almost quantitative yield. The pure sample, m.p. 109.7–110.7°, was obtained by recrystallization from isopropyl ether.

Anal. Calcd. for C₁₇H₁₆O: C, 86.4; H, 6.8. Found: C, 86.2; H, 7.0.

The nitrile, VIIIB, was obtained in 80% over-all yield from VIIB. A pure sample, m.p. 68.4–69.5°, was obtained by recrystallization from isopropyl ether.

Anal. Calcd. for C₁₈H₁₅N: C, 88.1; H, 6.2; N, 5.7. Found: C, 88.2; H, 6.1; N, 5.7.

4-(1-Anthryl)pentanoic acid, IXA, and 4-(1-anthryl)butyric acid, IXB. The crude nitrile, VIIIA, was saponified

(3) All melting points of pure compounds corrected.

(4) D. L. Turner, *J. Am. Chem. Soc.*, **76**, 5175 (1954).

(5) See expt. 26, M. S. Newman and F. J. Evans, Jr., *J. Am. Chem. Soc.*, **77**, 946 (1955).

(6) All analyses by the Galbraith Laboratory, Knoxville, Tenn.

(7) R. P. Linstead, *J. Chem. Soc.*, 1127 (1940).

(8) M. Orchin and O. Woolfolk, *J. Am. Chem. Soc.*, **68**, 1727 (1946).

to the acid, IXA, in 80% yield by heating at 180–200° for two hours with potassium hydroxide in diethylene glycol. Crystallization from isopropyl ether afforded IXA, m.p. 97–100°.

Anal. Calcd. for $C_{19}H_{18}O_2$: C, 82.0; H, 6.5. Found: C, 82.1; H, 6.7.

Similarly the nitrile, VIIIB, was converted into IXB in 85% yield, the hydrolysis being effected by heating in diethylene glycol at 120–145° for two hours. Recrystallization of the crude acid from isopropyl ether afforded pure IXB, m.p. 151.4–152.2°.

Anal. Calcd. for $C_{18}H_{16}O_2$: C, 81.8; H, 6.1. Found: C, 81.8; H, 6.3.

4'-Keto-1'-methyl-1',2',3',4'-tetrahydro-1,2-benzanthracene, XA, and 4'-keto-1',2',3',4'-tetrahydro-1,2-benzanthracene, XB. A mixture of 13.9 g. of crude acid, IXA, and 75 g. of polyphosphoric acid was heated at 80–110° for 45 min. The crude ketone, XA, m.p. 102–104°, was obtained in 80% yield. A pure sample, m.p. 105.0–106.5°, was obtained by chromatography over alumina and recrystallization from benzene and from isopropyl ether. A similar yield of crude ketone, XA, was obtained by cyclization of IXA with hydrogen fluoride.

Anal. Calcd. for $C_{19}H_{18}O$: C, 87.7; H, 6.2. Found: C, 87.9; H, 6.3.

In a similar way, IXB was cyclized to the ketone, XB, in 85% yield, with hydrogen fluoride. Pure XB, m.p. 189.0–198.6°, was obtained by crystallization from benzene-isopropyl ether.

Anal. Calcd. for $C_{18}H_{16}O$: C, 87.8; H, 5.7. Found: C, 88.0; H, 6.0.

1'-Methyl-1,2-benzanthracene, XIA, and 4'-methyl-1,2-benzanthracene, XIB. After reduction of 2.6 g. of XA with lithium aluminum hydride in ether the crude alcohol was dehydrated by boiling with xylene to which a trace of iodine had been added. The crude dehydration product was treated with a slight excess of sulfur and heated at 220–240° for 10 min. A small amount of zinc dust was added and the heat-

ing continued for 10 min. at 200–220°. The product was taken up in benzene, filtered, chromatographed over alumina, treated with charcoal (Darco G-60) in acetone, and crystallized from acetone and from benzene to yield XIA, m.p. 137–138°, in 60% yield based on XA. Further purification along the same lines afforded XIA,⁹ m.p. 139.2–139.9°.

A solution of 4.9 g. of XB in 200 ml. of tetrahydrofuran was added at 5–10° to the methyl lithium prepared from 5.5 g. of lithium and 57 g. of methyl iodide¹⁰ and the mixture was stirred for 30 min. After the usual workup the carbinol, m.p. 126–130°, was obtained in 85% yield. Without further purification the carbinol was dehydrated by boiling with xylene to which a trace of iodine had been added and the dehydration product was heated at 220–240° with a slight excess of sulfur for 10 min. Treatment with zinc dust and further treatment as above described for XIA afforded XIB, m.p. 190–192°, in 75% yield based on crude carbinol. Pure XIB,¹¹ 197.4–198.0°, was obtained after further crystallizations from acetone and benzene, and by chromatography over alumina.

COLUMBUS 10, OHIO

(9) For other syntheses of 1'-methyl-1,2-benzanthracene, see L. F. Fieser and A. M. Seligman, *J. Am. Chem. Soc.*, **60**, 170 (1938), J. W. Cook and A. M. Robinson, *J. Chem. Soc.*, 505 (1938), and W. E. Bachmann and R. O. Edgerton, *J. Am. Chem. Soc.*, **62**, 2550 (1940).

(10) K. Ziegler, *Ann.*, **479**, 135 (1930).

(11) For other syntheses of 4'-methyl-1,2-benzanthracene, see J. W. Cook, A. M. Robinson, and F. Goulden, *J. Chem. Soc.*, 505 (1938), C. Descamps and R. H. Martin, *Bull. soc. chim. Belges*, **61**, 223 (1952), B. M. Mikhailov and T. K. Kozminskaya, *Zhur. Obschei Khim.*, **23**, 1220 (1953); *Chem. Abstr.*, **47**, 12334 (1953); S. C. S. Gupta and D. N. Chatterjee, *J. Ind. Chem. Soc.*, **31**, 11 (1954).

[CONTRIBUTION FROM THE CHEMISTRY RESEARCH LABORATORY OF THE DEPARTMENT OF SURGERY, UNIVERSITY OF WASHINGTON]

Derivatives of Fluorene. V. 9-Hydroxyfluorenes; Reduction of Fluorenones in the Presence of Aralkylideneamino Groups¹

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Thirty-nine substituted 9-hydroxyfluorenes have been prepared and characterized. Sodium borohydride reduction of fluorenones is a convenient method for preparing many 9-fluorenols in good yields. Under certain conditions the —N=CH— group in some 2-aralkylideneaminofluorenones can be preserved while the carbonyl group is reduced. The reducibility of the —N=CH— group in 2-aralkylideneaminofluoren-9-ols can be made to vary by changing the type of para substituent in the aralkylidene group or by introducing a bromine in the 3-position of the fluorene moiety.

We have prepared³ a number of substituted 9-hydroxyfluorenes by sodium borohydride reduction of the corresponding fluorenones,⁴ and find that simplicity and high yields make this an excellent procedure (see Table I).

Upon being treated with sodium borohydride in our usual procedure, fluorenones with a ring —N=CHAr group gave mixtures including, in most instances, the corresponding benzylaminofluorenol compound. Billman and Diesing⁵ recently reported

(1) This investigation was supported in part by a grant (C-1744) from the National Cancer Institute of the National Institutes of Health, U. S. Public Health Service.

(2) To whom correspondence regarding this paper should be addressed.

(3) T. L. Fletcher and H. L. Pan, *J. Am. Chem. Soc.*, **78**, 4812 (1956).

(4) M. S. Newman and W. B. Lutz, *J. Am. Chem. Soc.*, **78**, 2469 (1956). These authors reported the reduction of fluorenone with sodium borohydride in acetonitrile and methanol, obtaining 84% of the 9-ol after 6-hr. reflux of the complex in 20% aqueous potassium fluoride and dioxane.

(5) J. H. Billman and A. C. Diesing, *J. Org. Chem.*, **22**, 1068 (1957).