m.p. 139–143°. It was recrystallized once from 0.5 cc. of ethyl alcohol and the crystals dried on a porous plate; m.p. 143–147°. The literature value for the di-*p*-bromophenacyl ester of sebacic acid is 147°.

The titrated fractions 10 through 16 were combined and evaporated to dryness. The solid residue was dissolved in 1 cc. of water to which was added 0.06 g. of *p*-bromophenacyl bromide dissolved in 2 cc. of ethanol. It was heated under reflux for two hours. A fine crystalline material was filtered and dried; m.p. 131°. An authentic sample of the di-*p*-bromophenacyl ester of azelaic acid was prepared; m.p. and mixed m.p. 131°.

Acknowledgment.—The author is indebted to Dr. Paul Sternglanz and Miss Vera Jane Wilson for the analyses reported in this work.

NEW HAVEN, CONNECTICUT

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, DUKE UNIVERSITY]

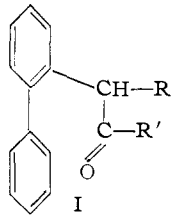
Aromatic Cyclodehydration. XXXII.[1] Loss of the Isopropyl Group on Cyclodehydration[2]

BY CHARLES K. BRADSHER AND DOROTHY J. BEAVERS[3]

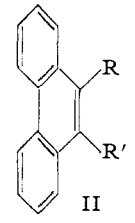
RECEIVED NOVEMBER 19, 1955

A direct and unambiguous synthesis of 9-isopropyl-10-methylphenanthrene (XI) has been accomplished. The instability of this hydrocarbon in the presence of boiling hydrobromic and acetic acids offers adequate explanation for the loss of isopropyl groups observed during the aromatic cyclodehydration of certain ketones and olefin oxides.

In an earlier communication[4] it was demonstrated that cyclodehydration of ketones of type I where R or R′ was the isopropyl group resulted in the elimination of the isopropyl group at some



I



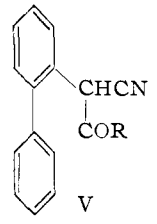
II

stage in the reaction yielding a 9-alkylphenanthrene II (R or R′ = H). It was also shown that an olefin oxide which might be expected to yield 9-isopropyl-10-isobutylphenanthrene afforded instead 9-isobutylphenanthrene.

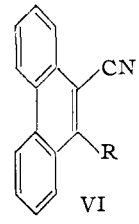
As was suggested earlier,[4] it seemed important to determine first whether 9-isopropyl-10-alkylphenanthrene (II, R = $CH(CH_3)_2$) would be stable in the boiling hydrobromic–acetic acid mixture used in the cyclization procedure. Since 9-methylphenanthrene crystallizes well and could be easily isolated from the "deisopropylation" experiment, the synthesis of 9-methyl-10-isopropylphenanthrene (II, R = CH_3, R′ = $CH(CH_3)_2$) was undertaken. Several unsuccessful attempts were made, but only two appear worthy of mention.

Syntheses starting from 10-bromo-9-methylphenanthrene (III)[5,6] appeared promising, but the hydrocarbon obtained in 23% yield by addition of isopropyl iodide to the lithium reagent formed from III by exchange with butyllithium proved to be 9-methyl-10-butylphenanthrene (IV).[4] Reaction of the same lithium reagent with acetone gave no identifiable addition product.

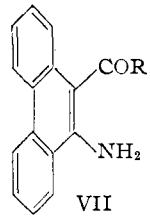
Previously[7] it has been found that α-acetyl- and α-propionyl-(2-biphenylyl)-acetonitriles (V, R = CH_3, C_2H_5) undergo cyclodehydration in the presence of boiling hydrobromic and acetic acids to yield 9-alkyl-10-phenanthronitrile (or the corresponding amide). Acylation of biphenylylacetonitrile with ethyl isobutyrate afforded the α-isobutyro-(2-biphenylyl)-acetonitrile (V, R = $(CH_3)_2CH$) in 63% yield. Unlike the lower homologs, V (R = CH_3, C_2H_5), the isobutyronitrile, when refluxed with hydrobromic and acetic acids, afforded only the corresponding hydrocarbon, 9-isopropylphenanthrene. Cyclization is slower with the larger, branched alkyl group so that hydrolysis of the nitrile group and decarboxylation of the resulting acid can occur prior to cyclization. A parallel observation has been made with α-benzoyl-(2-biphenylyl)-acetonitrile.[8]



V



VI



VII

With concentrated sulfuric acid the isobutyronitrile V (R = $(CH_3)_2CH$) cyclized to yield the desired 9-isopropyl-10-phenanthronitrile (54.5% yield) rather than 10-isobutyro-9-phenanthrylamine (VII, R = $(CH_3)_2CH$). The amine would have been expected if the nitrile group had excelled the carbonyl group in rate of attack on the adjacent phenyl group.[9] Under the same conditions the corresponding propionylacetonitrile V (R = C_2H_5) was found to cyclize to 9-ethyl-10-phenanthronitrile (VI, R = C_2H_5), in about the same yield. It was found that polyphosphoric acid was effective

(1) For the preceding communication of this series, see C. K. Bradsher and L. E. Beavers, THIS JOURNAL, **78**, 2459 (1956).

(2) This investigation was supported in part by a research grant (C-1743) from the National Cancer Institute of the National Institutes of Health, Public Health Service.

(3) Abstracted from a dissertation submitted in partial fulfillment of the degree of Doctor of Philosophy, 1955.

(4) C. K. Bradsher and W. J. Jackson, Jr., THIS JOURNAL, **76**, 4140 (1954).

(5) B. M. Mikhailov and N. G. Chernova, *J. Gen. Chem. of U.S.S.R.*, **21**, 1659 (1951).

(6) P. Lambert and R. H. Martin, *Bull. soc. chim. Belges*, **61**, 31 (1952).

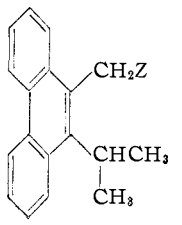
(7) C. K. Bradsher and W. J. Jackson, Jr., THIS JOURNAL, **76**, 734 (1954).

(8) C. K. Bradsher and R. S. Kittila, *ibid.*, **72**, 277 (1950).

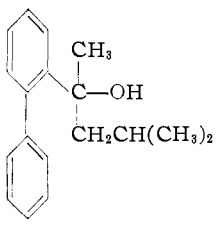
(9) C. K. Bradsher and D. J. Beavers, *ibid.*, **78**, 2153 (1956).

in bringing about the cyclization of V (R = $(CH_3)_2$-CH) in yields no better than those obtained by the sulfuric acid method.

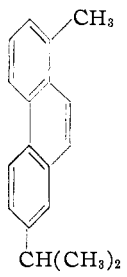
On reduction of the 9-isopropyl-10-phenanthronitrile (VI, R = $(CH_3)_2CH$) with lithium aluminum hydride the expected amine was isolated as the



VIII, Z = NH_3Cl
IX, Z = OH
X, Z = Br
XI, Z = H



XII



XIII

hydrochloride VIII in 69% yield. This was converted to the carbinol IX by the action of nitrous acid. Phosphorus tribromide converted the carbinol to the corresponding methyl bromide X which was reduced by lithium aluminum hydride in tetrahydrofuran producing the desired 9-isopropyl-10-methylphenanthrene (XI) in 92% yield. The new phenanthrene derivative proved identical with an unidentified substance prepared earlier[10] in this Laboratory. The sample had been prepared from the unsymmetrical carbinol XII by dehydration (which may occur in two different ways) followed by application of the olefin oxide[11] method for the synthesis of phenanthrene derivatives. Since at that time there appeared to be no simple way to determine whether the product was 9-isobutylphenanthrene or the isomeric 9-isopropyl-10-methylphenanthrene it had not been further investigated.[12]

When the 9-isopropyl-10-methylphenanthrene was dissolved in the usual hydrobromic–acetic acid cyclizing mixture and refluxed for 48 hours the isopropyl group was cleaved affording 9-methylphenanthrene in 73% yield.

This observation would appear to offer an adequate explanation for the "deisopropylative cyclodehydration" previously observed.[4]

The cyclodehydration step is probably normal and the dealkylation occurs only after the phenanthrene hydrocarbon is formed. The acid-catalyzed dealkylation of an aromatic hydrocarbon appears to be a rare phenomenon. The sulfuric acid-catalyzed intermolecular transfer of alkyl groups observed in the Jacobsen reaction[13] while resulting in the loss of an alkyl group from some of the molecules present is not a simple dealkylation and evidence has been presented that the reaction proceeds *via* the sulfonic acid rather than the hydrocarbon.[14] It is not surprising that 9-isopropyl-10-alkylphenanthrenes lose the isopropyl group in preference to the methyl or ethyl group present since the isopropyl group is capable of forming a more stable carbonium ion.[15] Yet it is not the isopropyl group *per se* which is responsible for the cleavage reaction, for retene XIII may be recovered (73%) unchanged after refluxing for 96 hours in the hydrobromic–acetic acid medium. While a similar test has never been run on 9-isopropylphenanthrene, this hydrocarbon has been prepared by aromatic cyclodehydration procedures involving refluxing periods of up to 90 hours without the detection of phenanthrene as a by-product. The greater lability of the isopropyl group in 9-isopropyl-10-alkylphenanthrenes is probably due to the strain introduced by crowding the two groups into the rather restricted space at the 9- and 10-positions. This crowding is easily seen in a model of the molecule. On the same basis one might predict that isopropyl mesitylene would likewise undergo deisopropylation in an acidic medium.

Experimental

Action of Butyllithium on 10-Bromo-9-methylphenanthrene (III).—Butyllithium was prepared from 6.48 g. of butyl bromide and 0.72 g. of lithium ribbon and 5 g. of 10-bromo-9-methylphenanthrene (III)[5,6] added at −10° dissolving and precipitating a few minutes later as the lithium derivative. After one hour, 11.6 g. of isopropyl iodide was added and the reaction mixture stirred overnight at room temperature. After decomposition of the reaction mixture with water and working up in the usual way, a yellow solid was obtained by evaporation of the ether. Twice recrystallized from ethanol this afforded 1.18 g. (26%) of pale yellow needles, m.p. 84–87°. The analytical sample melted at 89.5–90°.

Anal. Calcd. for $C_{19}H_{20}$: C, 91.88; H, 8.12. Found: C, 91.67; H, 8.10

By a mixed melting point determination the hydrocarbon was shown to be identical with an authentic sample[4] of 9-methyl-10-butylphenanthrene.

9-Methyl-10-phenanthryllithium seemed to react with acetone chiefly by enolization, the only identifiable product being 9-methylphenanthrene.

α-(2-Biphenylyl)-α-isobutyroacetonitrile (V, R = $(CH_3)_2$-CH).—Sodium amide was prepared as previously described[16] from 9.4 g. of sodium metal. To a suspension of the amide in dry ether, 31.5 g. of α-(2-biphenylyl)-acetonitrile in ether solution was added slowly (exothermic reaction). After the dark solution had been refluxed for one hour, 39.9 g. of ethyl isobutyrate was added. After the vigorous exothermic reaction had subsided the mixture was stirred overnight at room temperature. The mixture was poured on ice, acidified with hydrochloric acid and extracted with ether. The extract was washed, dried and evaporated and the product distilled under vacuum yielding 26.9 g. (63%) of a yellow oil, b.p. 173–180° (1 mm.), which quickly crystallized. The resulting solid was once recrystallized from methanol yielding tiny white prisms, m.p. 83–86.5°, which were not improved by further recrystallization.

Anal. Calcd. for $C_{18}H_{17}NO$: C, 82.10; H, 6.51; N, 5.32. Found: C, 82.13; H, 6.31; N, 5.33.

9-Isopropylphenanthrene (II, R = H, R′ = $(CH_3)_2CH$).—Five grams of the keto-nitrile V (R = $(CH_3)_2CH$) above, m.p. 83–86.5°, was dissolved in a mixture containing 100 ml. of acetic acid and 50 ml. of 48% hydrobromic acid and the solution refluxed overnight. The cooled solution was diluted, extracted with ether and the ethereal solution washed, dried and concentrated. The residue recrystallized from ethanol gave 2.3 g. of white crystalline material,

(10) S. T. Amore, Ph.D. Thesis, Duke University, 1944.
(11) C. K. Bradsher, THIS JOURNAL, **61**, 3131 (1939).
(12) It is interesting that this is the only example of an aromatic cyclodehydration yielding a 9-isopropyl-10-alkylphenanthrene. The explanation for this may be in Amore's use of 34% hydrobromic acid for 24 hours instead of 48% acid for 48 hours as commonly used in the dealkylative cyclizations (ref. 4).
(13) L. I. Smith, "Organic Reactions," John Wiley and Sons, Inc., New York, N. Y., 1942, Vol. I, p. 370.
(14) L. I. Smith and O. W. Cass, THIS JOURNAL, **54**, 1614 (1932).
(15) E. R. Alexander, "Principles of Ionic Reactions," John Wiley and Sons, Inc., New York, N. Y., 1950, p. 4.
(16) C. R. Hauser and R. Levine, THIS JOURNAL, **68**, 760 (1946).

m.p. 38–41°. The purest sample obtained melted at 40–41° (lit.[17] 41–42°).

9-Isopropyl-10-phenanthronitrile (VI, R = $(CH_3)_2CH$). (a) By the Action of Sulfuric Acid.—Concentrated sulfuric acid (250 ml.) was cooled to 0° and stirred while 24 g. of α-(2-biphenylyl)-isobutyroacetonitrile (V, R = $(CH_3)_2$-CH) was added at such a rate that the temperature did not exceed 7°. After it had been stirred for an additional three hours the deep-green solution was poured on 500 g. of ice. The resulting white solid was collected, neutralized with alkali and extracted with ether. The ethereal extract was washed, dried and concentrated yielding a crude tan material. This material, recrystallized from ethanol, afforded 12.5 g. (54.5%) of yellow prisms, m.p. 131–134°.

An analytical sample purified by recrystallization and sublimation consisted of white prisms, m.p. 134–135.5°.

(b) By Action of Polyphosphoric Acid.—One gram of the isobutyroacetonitrile V (R = $(CH_3)_2CH$) was heated and mechanically stirred with 20 ml. of polyphosphoric acid[18] for 28 hours at 80–85°. The light brown liquid when poured on ice gave a gum which disintegrated upon addition of a saturated solution of sodium carbonate. The basic solution was extracted with ether and the washed and dried ethereal solution was concentrated. The residue was taken up in ethanol, treated with Darco (activated carbon), and filtered through a Hyflo-bed. The product crystallized as yellow prisms, m.p. 130–134°, yield 0.44 g. (48%).

Anal. Calcd. for $C_{18}H_{15}N$: C, 83.13; H, 6.16. Found (a): C, 83.13; H, 6.12.

An infrared absorption spectrum showed a strong band at 4.51 μ.[19]

9-Ethyl-10-phenanthronitrile (VI, R = C_2H_5).—When 1.17 g. of α-(2-biphenylyl)-α-propionylacetonitrile was dissolved in 12 ml. of cold concentrated sulfuric acid at 0° and after three hours worked up as in the case of the homolog VI (R = $(CH_3)_2CH$) it afforded 0.64 g. (54%) of yellow platelets from methanol, m.p. 136–139°.

The analytical sample was prepared by recrystallization from methanol (Darco) and formed white platelets, m.p. 140–142°.

Anal. Calcd. for $C_{17}H_{13}N$: C, 88.28; H, 5.67. Found: C, 88.00; H, 5.63.

9-Isopropyl-10-phenanthrylmethylamine Hydrochloride (VIII).—About 500 ml. of dry ether was placed in a one-liter flask equipped with stirrer, Soxhlet extractor and condenser with drying tube. After sweeping out the system with nitrogen, 2.55 g. of lithium aluminum hydride was added and the ether refluxed to dissolve the 11.0 g. of 9-isopropyl-10-phenanthronitrile contained in the thimble of the Soxhlet apparatus. After three hours all of the material in the thimble had dissolved, but refluxing was continued for seven additional hours after which stirring was continued overnight at room temperature. A vigorous reaction ensued when the mixture was decomposed by addition of 3 ml. of water, 4 ml. of 20% sodium hydroxide solution and 14 ml. of water; a white precipitate formed.[20] The ether was decanted and the precipitate washed with ether. Anhydrous hydrogen chloride was passed through the combined ethereal solutions causing the formation of a pale yellow solid, m.p. 247–250°, yield 8.82 g. (69%).

An analytical sample obtained as beautiful white needles, m.p. 258.5–259.5° from absolute ethanol–ether, appeared to crystallize with one-half molecule of ether of crystallization.

Anal. Calcd. for $(C_{18}H_{20}NCl)_2 \cdot C_4H_{10}O$: C, 74.40; H, 7.81. Found: C, 74.47; H, 7.71.

9-Isopropyl-10-phenanthrylcarbinol (IX).—The crude amine hydrochloride (VIII, 8.5 g.) was dissolved in 35 ml. of glacial acetic acid and 10 ml. of water. The solution was cooled to 10° and 5.17 g. of sodium nitrite in 10 ml. of water was added to the orange solution with stirring. There was considerable foaming in the exothermic reaction. The temperature was kept below 25° by external cooling. A gum separated and floated to the surface of the liquid. After two hours the liquid was further diluted with water and extracted with methylene chloride.

The oil left by the evaporation of the methylene chloride was refluxed with 125 ml. of 5% ethanolic potassium hydroxide to hydrolyze any carbinol acetate which may have been formed.[21] After three hours the solution was cooled, diluted and extracted with ether. The ethereal extract was washed, dried and concentrated leaving dark orange prisms. The crude product was recrystallized first from methanol (Darco), then from dilute ethanol, and finally from benzene, yielding 3.2 g. (43%) of tiny white prisms, m.p. 135.5–138°. The analytical sample was obtained from benzene as white cubes, m.p. 136.5–138°.

Anal. Calcd. for $C_{18}H_{18}O$: C, 86.36; H, 7.25. Found: C, 86.43; H, 7.39.

9-Isopropyl-10-phenanthrylmethyl Bromide (X).—A solution of the carbinol (IX, 2.5 g.) in 100 ml. of dry ether was cooled to 0° and 2 ml. of phosphorus tribromide added. After the mixture had stood for 4 hours the excess reagent was destroyed by addition of 5 ml. of methanol. The ethereal solution was washed and then evaporated. The resulting product, twice recrystallized from benzene–hexane, yielded 2.5 g. (82.5%) of white prisms, m.p. 118.5–120°. The analytical sample melted at 118–119.5°.

Anal. Calcd. for $C_{18}H_{17}Br$: C, 69.01; H, 5.47. Found: C, 69.37; H, 5.49.

9-Isopropyl-10-methylphenanthrene (XI). (a) By Hydrogenolysis of the Bromo Derivative (X).[22]—A mixture of 25 ml. of dry tetrahydrofuran and 220 mg. of lithium aluminum hydride was heated on the steam-bath and stirred while a solution containing 1.75 g. of 9-isopropyl-10-phenanthrylmethyl bromide (X) in 10 ml. of dry tetrahydrofuran was added dropwise. The reaction mixture was refluxed for two hours and then poured into a mixture of ice and sulfuric acid. The material which separated was taken up in ether and the ethereal solution washed, filtered and evaporated. The pale residual oil was crystallized from ethanol affording 1.2 g. (92%) of white prisms, m.p. 96–98.5°. When recrystallized several times from alcohol, it melted at 98–100.5°.

(b) From Methyl Isobutyl Ketone by the Olefin Oxide Method.[23]—The crude carbinol XII obtained by reaction of 14 g. of methyl isobutyl ketone with an excess of 2-biphenylylmagnesium iodide was heated with two to three times its weight of potassium bisulfate for one hour at 160°. The product extracted with benzene and distilled *in vacuo* afforded a light yellow oil, b.p. 139–145° (9 mm.), yield 12 g. (36%). This material contained a small quantity of biphenyl, but was satisfactory for conversion to the olefin oxide. The olefin was treated at 0° with a 20% excess of perbenzoic acid[24] in chloroform solution and allowed to stand for 24 hours in the refrigerator. The chloroform solution was washed with sodium bicarbonate solution and then concentrated. The residual oil was dissolved in 80 ml. of glacial acetic acid, 40 ml. of 34% hydrobromic acid added and the mixture refluxed for 24 hours. The product isolated from the cooled and diluted acid by means of ether extraction, distillation *in vacuo* and many recrystallizations from ethanol afforded 0.5 g. of tiny white prisms, m.p. 99–100.2°. Samples prepared by methods a and b showed no depression of melting point when mixed.

Anal. Calcd. for $C_{18}H_{18}$: C, 92.31; H, 7.70. Found (sample b): C, 92.06; H, 7.75.

Deisopropylation of 9-Isopropyl-10-methylphenanthrene (XI).—One-half gram of 9-isopropyl-10-methylphenanthrene (XI, m.p. 97–98.5°) was dissolved in 11 ml. of glacial acetic acid, 5.5 ml. of 48% hydrobromic acid added and the mixture refluxed for 48 hours. Upon cooling the mixture, the hydrocarbon separated and was recrystallized from methanol yielding 0.30 g. (73%) of 9-methylphenanthrene, m.p. 89–91° (lit.[25] 91–92°) which did not depress the melting point of an authentic sample.

(17) C. K. Bradsher and S. T. Amore, THIS JOURNAL, **63**, 494 (1941).

(18) We are indebted to the Victor Chemical Co., for this reagent.

(19) The stretching frequency of the CN band for aromatic nitriles has been reported to be 4.46–4.50 μ, R. E. Kitsen and N. E. Griffith, *Anal. Chem.*, **24**, 334 (1952).

(20) *Cf.* L. H. Amundsen and L. S. Nelson, THIS JOURNAL, **73**, 242 (1951).

(21) C. K. Bradsher and W. J. Jackson, Jr., *ibid.*, **74**, 4880 (1952).

(22) *Cf.* J. E. Johnson, R. H. Blizzard and H. W. Carhart, *ibid.*, **70**, 3664 (1948).

(23) We are indebted to Dr. S. T. Amore for this experiment (ref. 10).

(24) G. Braun, *Org. Syntheses*, **13**, 86 (1933).

(25) A. Windaus, *Ann.*, **439**, 59 (1924).

Action of Hydrobromic Acid on Retene (XIII).—Five grams of retene (m.p. 97.5–99.5°) (XIII) was refluxed for 96 hours in a mixture containing 100 ml. of glacial acetic acid and 50 ml. of concentrated hydrobromic acid. The product which separated on cooling yielded 3.67 g. (73%) of pink platelets, m.p. 95–98°, which did not depress the melting point of retene. Further concentration yielded an additional 0.85 g. of slightly less pure material.

DURHAM, N. C.

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, DUKE UNIVERSITY]

Aromatic Cyclodehydration. XXXIII.[1] 2,7-Disubstituted Phenanthrenes[2,3]

BY CHARLES K. BRADSHER, LEO E. BEAVERS[4] AND NIICHIRO TOKURA

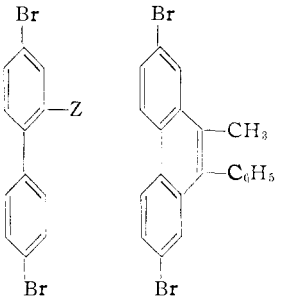
RECEIVED NOVEMBER 19, 1955

Starting in each case with biphenyl derivatives prepared from suitably substituted fluorenones, 2,7-dibromo-9-methyl-10-phenyl- and 2,7-dimethoxy-9-ethyl-10-(*p*-methoxyphenyl)-phenanthrene have been prepared by the aromatic cyclodehydration method. Some new derivatives of 2′,4′-dimethoxybiphenyl-2-carboxylic acid have been prepared.

In earlier papers[5,6] it was pointed out that 9-phenylphenanthrene may be regarded as a closed model of the physiologically active[7,8] triphenylethylene system. As part of a continuation of this study we have undertaken the preparation of two 9-phenylphenanthrene derivatives bearing substituents in both of the terminal rings of the phenanthrene nucleus. This represents the first attempt to prepare such terminally disubstituted phenanthrenes by aromatic cyclodehydration, although monosubstituted analogs were prepared earlier by this method.[5,9]

As a starting material 4,4′-dibromobiphenyl-2-carboxylic acid (I) was used. The methyl ester II

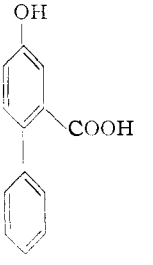
I, Z = COOH
II, Z = $COOCH_3$
III, Z = CH_2OH
IV, Z = CH_2Br
V, Z = CH_2CN
VI, Z = CH_2CONH_2
VII, Z = $CH(CH_3)CN$
VIII, Z = $CH(CH_3)COC_6H_5$

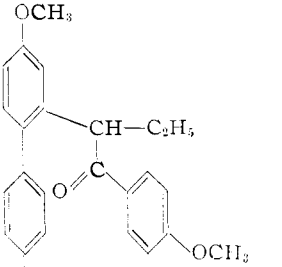


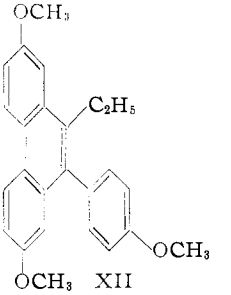
IX

was reduced with lithium aluminum hydride (89% yield), and the resulting carbinol III treated with phosphorus tribromide to yield the bromide IV. Treatment of the bromide with potassium cyanide in ethanol–water afforded a mixture containing the nitrile V (82%) and the corresponding amide VI (3.5%). The nitrile V was alkylated in the usual way using methyl iodide, and the resulting nitrile VII treated with phenylmagnesium bromide affording the expected ketone VIII. When the ketone VIII was refluxed for one week with the usual hydrobromic–acetic acid mixture, only a small quantity of the expected cyclization product was obtained,[10] and this was very difficult to separate from unchanged starting material. Much better results (83.5%) were obtained using concentrated sulfuric acid as the cyclizing medium. The overall yield from the 4,4′-dibromobiphenyl-2-carboxylic acid (I) was 29%. The new 2,7-dibromo-9-methyl-10-phenylphenanthrene (IX) is a colorless crystalline solid, m.p. 127–127.5°.

Similar methods were used in the preparation of 2,7-dimethoxy-9-ethyl-10-(*p*-methoxyphenyl)-phenanthrene (XII) starting from the known 4,4′-







dihydroxy-2-biphenylylcarboxylic acid (X). This, like the analogous dibromo acid I, was pre-

(1) For the preceding communication of this series see THIS JOURNAL, **78**, 3193 (1956).

(2) This investigation was supported in part by a research grant (C-1743) from the National Cancer Institute of the National Institutes of Health, Public Health Service.

(3) Abstracted in part from a thesis submitted by Leo E. Beavers in partial fulfillment of the requirements for the degree of Doctor of Philosophy, 1955.

(4) Public Health Service Research Fellow of the National Institutes of Health (1952–1954).

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(9) C. K. Bradsher and L. J. Wissow, THIS JOURNAL, **68**, 1094 (1946).

(10) The slow rate of cyclization could be predicted from the known deactivating influence of a halogen substituent upon an aromatic nucleus. A similar effect was observed on cyclizing *meta* to a chlorine substituent (ref. 9).