Cyclo-ψ-smilagenin: R.D.: $[\alpha]_{700}$ −50°, $[\alpha]_{589}$ −62°, $[\alpha]_{300}$ −305°; *c* 0.10, temp. 25°.

Sarsasapogenin (Xa).—R.D. (Fig. 1): $[\alpha]_{700}$ −53°, $[\alpha]_{589}$ −82°, $[\alpha]_{300}$ −351°; *c* 0.08, temp. 30°.

Cyclo-ψ-sarsasapogenin (Xb).—R.D. (Fig. 1): $[\alpha]_{700}$ +32°, $[\alpha]_{589}$ +37°, $[\alpha]_{300}$ +196°; *c* 0.11, temp. 24°.

Yuccagenin (VIII).—R.D. (Fig. 2): $[\alpha]_{700}$ −80°, $[\alpha]_{589}$ −108°, $[\alpha]_{300}$ −556°; *c* 0.11, temp. 25°.

Yuccagenin Diacetate.—R.D.: $[\alpha]_{700}$ −98°, $[\alpha]_{580}$ −134°, $[\alpha]_{300}$ −643°; *c* 0.11, temp. 30°.

Kammogenin (IX).—R.D. (Fig. 2): $[\alpha]_{700}$ −28°, $[\alpha]_{589}$ −51°, $[\alpha]_{290}$ −337°; "min." $[\alpha]_{385}$ −84°; "max." $[\alpha]_{315}$ +424°; *c* 0.10, temp. 25°; u.v. λ_{max} 288 mμ, log ε 1.65.

Samogenin (XI).—R.D. (Fig. 2): $[\alpha]_{700}$ −60°, $[\alpha]_{589}$ −82°, $[\alpha]_{300}$ −350°; *c* 0.08, temp. 24°.

Mexogenin (XII).—R.D. (Fig. 2): $[\alpha]_{700}$ −7°, $[\alpha]_{589}$ −6°, $[\alpha]_{300}$ +324°; "max." $[\alpha]_{315}$ +802°; *c* 0.10, temp. 25°; u.v. λ_{max} 290 mμ, log ε 1.62.

Tigogenone (XVII).—R.D. (Fig. 3): $[\alpha]_{700}$ −39°, $[\alpha]_{589}$ −56°, $[\alpha]_{280}$ −175°; "min." $[\alpha]_{395}$ −99°; "max." $[\alpha]_{315}$ +326°; "min." $[\alpha]_{295}$ −569°; *c* 0.08, temp. 24°.

22a,25a,5α-Spirostan-3β-ol-7-one (XVIII).—R.D. (Fig. 3): $[\alpha]_{700}$ −78°, $[\alpha]_{589}$ −103°, $[\alpha]_{290}$ −286°; "min." $[\alpha]_{315}$ −598°; *c* 0.10, temp. 30°; u.v. λ_{max} 284 mμ, log ε 1.53.

22a,25a,5α-Spirostan-2α,3β-diol-15-one Diacetate (XIX).—R.D. (Fig. 3): $[\alpha]_{700}$ −55°, $[\alpha]_{589}$ −74°, $[\alpha]_{290}$ −1472°; "min." $[\alpha]_{450}$ −103°; "max." $[\alpha]_{325}$ +949°; "min." $[\alpha]_{295}$ −1510°; *c* 0.09, temp. 25°; u.v. flat λ 280–305 mμ, log ε 1.55.

Kryptogenin Diacetate (XX).—R.D. (Fig. 3): $[\alpha]_{700}$ −133°, $[\alpha]_{589}$ −182°, $[\alpha]_{300}$ −960°; "min." $[\alpha]_{320}$ −3105°; *c* 0.08, temp. 23°.

Hecogenin Acetate (XIII).—R.D. (Fig. 4): $[\alpha]_{700}$ −13°, $[\alpha]_{589}$ −10°, $[\alpha]_{290}$ + 154°; "max." $[\alpha]_{312.5}$ +783°; *c* 0.09, temp. 28°; u.v. λ_{max} 280 mμ, log ε 1.79.

11α,23-Dibromo-hecogenin Acetate (XIV).—R.D. (Fig. 4): $[\alpha]_{700}$ −21°, $[\alpha]_{589}$ −26°, $[\alpha]_{300}$ +227°; "min." $[\alpha]_{340}$ −287°; *c* 0.08, temp. 25°; u.v. flat λ 275–288 mμ, log ε 1.90.

12α,23-Dibromo-11-keto-tigogenin Acetate (XVI).—R.D. (Fig. 4): $[\alpha]_{700}$ −41°, $[\alpha]_{589}$ −70°, $[\alpha]_{300}$ +1319°; "min." $[\alpha]_{345}$ −1566°; *c* 0.07, temp. 29°; u.v. λ_{max} 316 mμ, log ε 2.21.

23-Bromo-desoxytigogenin (XXI).—R.D. (Fig. 4): $[\alpha]_{700}$ −54°, $[\alpha]_{589}$ −82°, $[\alpha]_{300}$ −358°; *c* 0.07, temp. 28°.

11-Keto-tigogenin (XV).—R.D. (Fig. 5): $[\alpha]_{700}$ −32°, $[\alpha]_{589}$ −31°, $[\alpha]_{300}$ −226°; "min." $[\alpha]_{410}$ −57°; "max." $[\alpha]_{325}$ + 133°; *c* 0.11, temp. 26°; u.v. λ_{max} 290 mμ, log ε 1.62.

Δ⁵-22a,25a,5α-Spirosten-3β-ol-11-one (XXII).—R.D. (Fig. 5): $[\alpha]_{700}$ +63°, $[\alpha]_{589}$ +89°, $[\alpha]_{290}$ +1707°; "max." $[\alpha]_{450}$ + 144°; "min." $[\alpha]_{445}$ + 137°; "max." $[\alpha]_{440}$ +144°; "min." $[\alpha]_{425}$ +132°; "max." $[\alpha]_{420}$ +143°; "min." $[\alpha]_{387.5}$ −36°; "max." $[\alpha]_{382.5}$ −11°; "min." $[\alpha]_{380}$ −28°; "max." $[\alpha]_{377.5}$ −26°; "min." $[\alpha]_{375}$ −29°; "max." $[\alpha]_{300}$ +2371°; *c* 0.08, temp. 29°; u.v. flat λ 314–333 mμ, log ε 1.89.

Δ⁵-22a,25a,5α,14β-Spirosten-3β-ol-11-one (XXIII).—R.D. (Fig. 5): $[\alpha]_{700}$ +75°, $[\alpha]_{589}$ +116°, $[\alpha]_{285}$ +1204°; "max." $[\alpha]_{427.5}$ +258°; "min." $[\alpha]_{425}$ +255°; "max." $[\alpha]_{405}$ +304°; "min." $[\alpha]_{400}$ +302°; "max." $[\alpha]_{397.5}$ +312°; "min." $[\alpha]_{395}$ +307°; "max." $[\alpha]_{290}$ +1799°; *c* 0.06, temp. 30°; u.v. λ_{max} 330 mμ, log ε 1.81.

22a,25a,5α,8α-Spirostan-3β-ol-11-one (XXIV).—R.D. (Fig. 5): $[\alpha]_{700}$ −51°, $[\alpha]_{589}$ −60°, $[\alpha]_{290}$ −490°; "min." $[\alpha]_{400}$ −100°; "max." $[\alpha]_{330}$ +183°; *c* 0.10, temp. 28°.

22a,25a,5α,14β-Spirostan-3β-ol-11-one (XXV).—R.D. (Fig. 5): $[\alpha]_{700}$ +8°, $[\alpha]_{589}$ +10°, $[\alpha]_{290}$ +97°; "max." $[\alpha]_{325}$ +419°; *c* 0.11, temp. 24°; u.v. flat λ 296–308 mμ, log ε 1.62.

Δ⁴-22a,25a-Spirosten-3-one (XXVI).—R.D. (Fig. 6): $[\alpha]_{700}$ +7°, $[\alpha]_{589}$ −14°, $[\alpha]_{290}$ +1014°; "min." $[\alpha]_{365}$ −371°; "max." $[\alpha]_{360}$ −339°, "min." $[\alpha]_{352.5}$ −479°; "max." $[\alpha]_{340}$ −41°; "min." $[\alpha]_{337.5}$ −58°, "max." $[\alpha]_{302.5}$ +1191°; "min." $[\alpha]_{300}$ +1157°; "max." $[\alpha]_{295}$ +1182°; *c* 0.04, temp. 27°.

Δ¹,⁴,⁶-22a,25a-Spirostatrien-3-one (XXVII).—R.D. (Fig. 6): $[\alpha]_{700}$ −87°, $[\alpha]_{589}$ −114°, $[\alpha]_{300}$ −105°; "min." $[\alpha]_{550}$ −121°; "max." $[\alpha]_{405}$ +973°; "min." $[\alpha]_{390}$ +536°; "max." $[\alpha]_{385}$ +554°; "min." $[\alpha]_{335}$ −3272°; "max." $[\alpha]_{320}$ −5°; *c* 0.06, temp. 24°.

Δ⁵-22a,25a,5α-Spirosten-3β-ol-7,11-dione Acetate (XXVIII).—R.D. (Fig. 6): $[\alpha]_{700}$ +12°, $[\alpha]_{589}$ +19°, $[\alpha]_{300}$ +650°; "max." $[\alpha]_{520}$ +25°; "min." $[\alpha]_{450}$ −37°; "max." $[\alpha]_{330}$ +840°; *c* 0.06, temp. 25°.

11-Ketohecogenin (XXIX).—R.D. (Fig. 6): $[\alpha]_{700}$ −16°, $[\alpha]_{589}$ −8°, $[\alpha]_{300}$ −102°; "min." $[\alpha]_{365}$ −62°; "max." $[\alpha]_{362.5}$ −60°, "min." $[\alpha]_{350}$ −100°; "max." $[\alpha]_{345}$ −79°; "min." $[\alpha]_{340}$ −88°; "max." $[\alpha]_{320}$ +249°; "min." $[\alpha]_{305}$ −88°; *c* 0.09, temp. 25°.

Botogenin Acetate (Gentrogenin Acetate[9a]).—R. D.: $[\alpha]_{700}$ −53°, $[\alpha]_{589}$ −70°, $[\alpha]_{285}$ −896°; "min." $[\alpha]_{410}$ −116°, "max." $[\alpha]_{315}$ +585°; *c* 0.1, temp. 25°.

DETROIT, MICHIGAN

[CONTRIBUTION NO. 191 FROM JACKSON LABORATORY, E. I. DU PONT DE NEMOURS & CO.]

Condensation of Phthalideneacetic Acid with Naphthalenes to Form Benzopyrenequinones

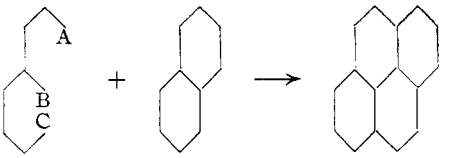
BY H. E. SCHROEDER, F. B. STILMAR AND F. S. PALMER

RECEIVED JUNE 22, 1955

An unusual and remarkably simple one-step synthesis of benzopyrenequinones has been found in the condensation of phthalideneacetic acid with naphthalenes in the presence of anhydrous hydrogen fluoride at moderate temperatures. It is applicable to naphthalene and homologs, fluoranthene and anthracene.

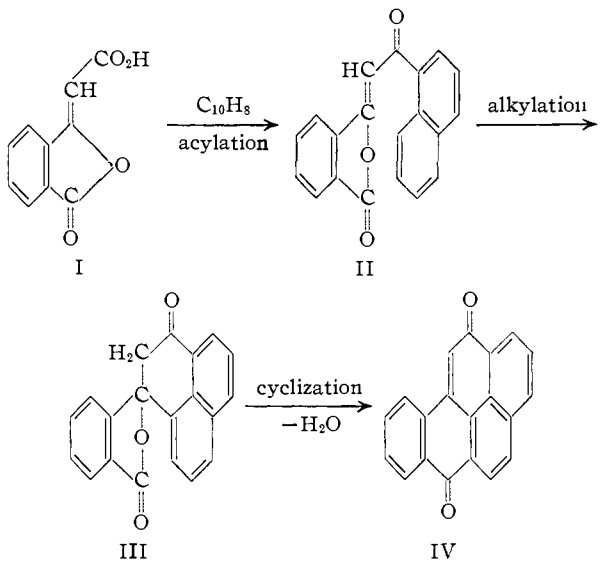
Studies of polynuclear substances frequently are hampered by the difficulty of synthesizing the specific derivatives needed. Furthermore, because of the many steps involved, customary procedures which involve cyclization of properly fashioned side chains into *ortho* or peri positions usually give inadequate yields of products.

In a search for more effective reactions for synthesis of polynuclear compounds, which would permit joining of larger fragments in a specific manner, attention was focused on simultaneous attack at the 1-, 2- and 8-positions in a naphthalene nucleus by use of six-membered carbon chains with functional groups appropriately situated as indicated.



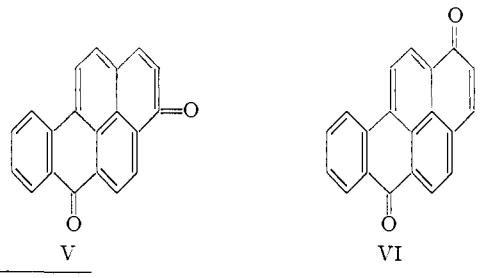
Phthalideneacetic acid[1] appeared particularly well suited to such an approach since it should afford a 3,4-benzopyrene-1,5-quinone (benzo[a]pyrene-6,12-dione) as schematically illustrated by

(1) S. Gabriel and A. Michael, *Ber.*, **10**, 1554 (1877); S. Gabriel and A. Neumann, *ibid.*, **26**, 952 (1893).



Since anhydrous hydrogen fluoride is inherently capable of effecting all of these reactions,[2] a mixture of phthalideneacetic acid and naphthalene was treated with anhydrous hydrogen fluoride for 16 hours at 40°. The reaction afforded in about 95% yield a mixture of an alkali-insoluble yellow quinone (IV) 55%, and a bright yellow bicarbonate-soluble acid, 40%.[3] Subsequent variations in the synthetic procedure indicated that yields of quinone as high as 70% were possible, the remainder being the alkali-soluble portion whose identity will be discussed below.

The alkali-insoluble portion is clearly the desired 3,4-benzopyrene-1,5-quinone (IV) as expected from the synthetic method employed. The analyses indicate the product as that obtained by reaction of phthalideneacetic acid and naphthalene with elimination of two molecules of water. The presence of the benzopyrene nucleus was established by zinc dust distillation to give 3,4-benzopyrene (m.p. 177–178°; m.p. of trinitrobenzene complex, 223–224°). Both the 3,4-benzopyrene and the trinitrobenzene complex were found identical with authentic samples[4] prepared by another route. The quinone is readily soluble in alkaline hydrosulfite to form an orange solution (vat) from which the starting material is regenerated on air oxidation. The purified product melting at 327°, giving a red solution in sulfuric acid, is a new amphiquinone clearly different from the 3,6-quinone, m.p. 245° (V) or the 1,6-quinone m.p. 295° (VI).[5] On reductive acylation with zinc, acetic anhydride and triethylamine catalyst, it is converted to the hydroquinone diacetate from which the benzopyrenequinone can be recovered on oxidation.



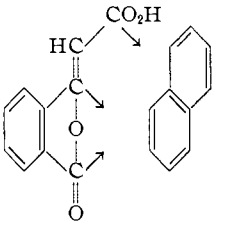
This is truly a remarkable reaction since it affords in one step from simple intermediates a pentacyclic ring system by a startling coincidence which involves three specific positions in the phthalideneacetic acid which must attack three positions (alpha, beta and peri) in the naphthalene in the proper order. In view of its success with naphthalene, the synthesis was explored with a variety of aromatic substances possessing the requisite free positions in the hope that it might be generally applicable. These included substituted naphthalenes, anthracene, pyrene, phenanthrene, chrysene, fluoroanthene and perylene. In almost every case, a reaction occurred to yield highly colored substances which could be separated into two fractions; one soluble in bicarbonate or carbonate and usually representing elimination of one mole of water from the reactants, and the other more deeply colored, analytically corresponding to elimination of two moles of water. By raising the temperature in many cases, the reaction could be directed almost entirely toward the alkali-insoluble material giving yields as high as 96%.

Closer examination revealed that two types of alkali-insoluble products were being obtained, depending upon the starting materials employed.

1. Naphthalene, methylnaphthalenes, anthracene and fluoranthene yielded vattable substances, probably quinones homologous with the benzopyrenequinone. Only the product from naphthalene was studied in detail.

2. Chloro-, bromo-, methoxy- and methylthionaphthalenes, pyrene, perylene and chrysene yielded more deeply colored, reducible, but not vattable, substances of uncertain structure. These will be discussed in a subsequent paper.

Phthalideneacetic Acid Condensations.—The condensation of phthalideneacetic acid with naphthalene to produce 3,4-benzopyrene-1,5-quinone involves a minimum of three concurrent or consecutive reactions in which the functional groups of the phthalideneacetic acid attack the appropriate 1, 2 and 8-positions in the naphthalene nucleus with resultant condensation to form the quinone. The benzopyrenequinone can result only if the aliphatic carboxyl and the β-carbon of the acrylic acid structure become attached in the peri positions of the naphthalene; the aromatic carboxyl must then condense in a β-position.



The sequence of steps involved in this reaction is

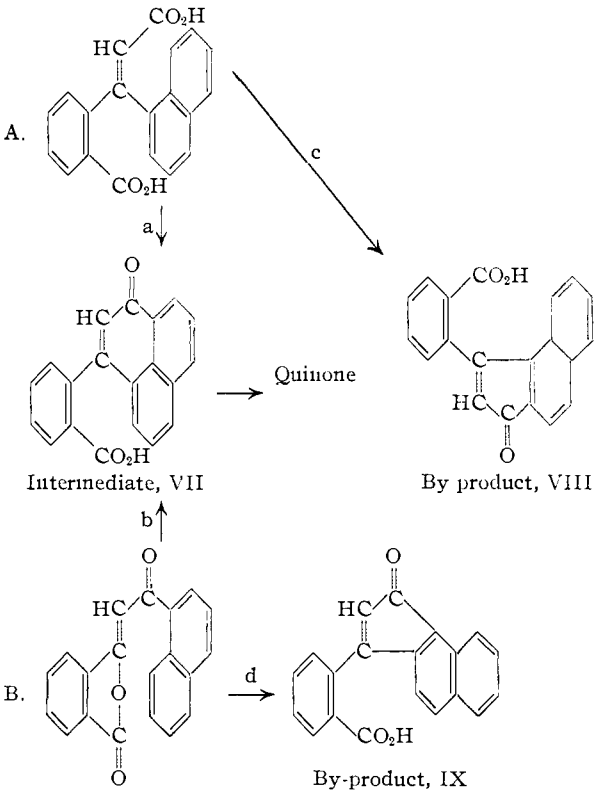
(2) W. S. Calcott, J. M. Tinker and V. Weinmayr, THIS JOURNAL, **61**, 949, 1010 (1939); L. F. Fieser and E. B. Hershberg, *ibid.*, **61**, 1272 (1939).

(3) H. E. Schroeder, U. S. 2,693,953 (issued Sept. 29, 1953).

(4) Samples furnished by Prof. L. F. Fieser, Harvard University.

(5) (a) H. Vollmann, *et al.*, *Ann.*, **531**, 51 (1937); (b) A. Windaus and K. Raichle, *ibid.*, **537**, 157 (1939); E. Clar, "Aromatische Kohlenwasserstoffe," Springer-Verlag, Berlin, 1951.

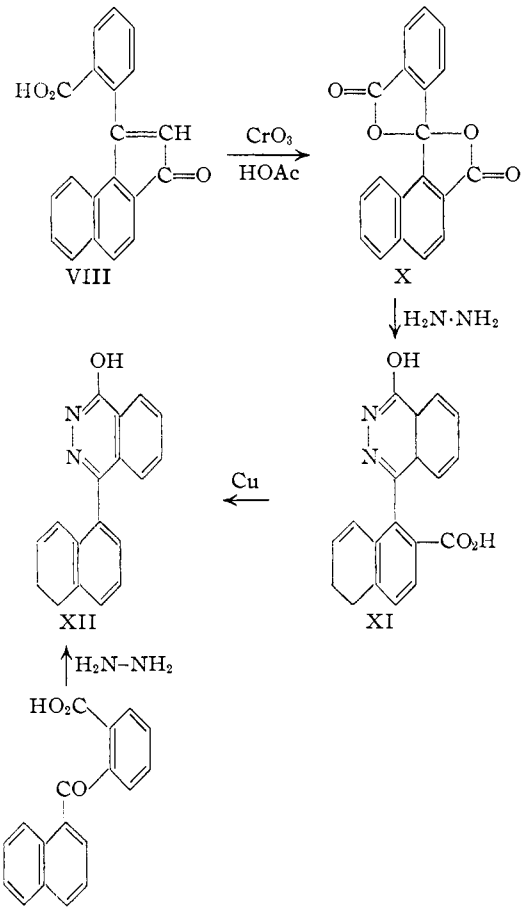
of prime importance since it will determine whether this novel reaction can be applied to any particular polynuclear system. The most probable course involves condensation of either the aliphatic carboxylic acid group or the olefinic linkage of the phthalideneacetic acid in one α-position, and subsequent condensation of the other group in the peri position to form the 6-membered ring as in VII. This is followed by ring closure of the aromatic carboxyl group in VII to form the quinone. These reactions with the possible by-products which might arise are illustrated in the following



By course (a) involving the olefinic β-carbon of phthalideneacetic acid, condensation to a quinone is possible only if there are unsubstituted β- and peri-positions adjacent to the α-position initially attacked in A. In this case reaction (a) must ultimately yield quinone. An alternate possibility, in which the acid (A) rotates about the initial point of attack and the aliphatic carboxyl group acylates the naphthalene in the 2-position, leads by course (c) to a phenylbenzindenonecarboxylic acid (VIII) which cannot be cyclized to form a quinone. Substances in which the β-position (adjacent to the alpha attacked) is occupied, *e.g.*, 2-methylnaphthalene, could not be cyclized to quinones.

If the reaction follows course (b) involving the aliphatic carboxyl group, cyclization involving attack of the olefinic β-carbon of the acrylic acid will yield the same intermediate VII and ultimately quinone. The other possibility (d), of cyclization to the 2-naphthalene position, will give another benzindenone derivative IX which cannot yield quinone. By (b) it should be possible to effect successful condensations with polynuclear hydrocarbons possessing a suitably activated α-position and unsubstituted α- and β-positions in the other ring, *e.g.*, anthracene, acenaphthene, pyrene, 1- and 2-substituted naphthalenes. Another possibility, involving initial condensation of the aromatic carbonyl group in a β-position of the naphthalene nucleus probably does not occur to any appreciable extent since alpha activated naphthalenes such as 1-chloro- and 1- and 2-methyl-naphthalenes appear to afford condensation products, and also since acylation of naphthalene usually occurs in the 1-position.

Some light is shed on this question by examination of the structure of the by-product formed in condensation with naphthalene. A 25–40% yield is obtained of an acidic yellow compound which possesses the empirical formula $C_{20}H_{12}O_3$ (m.p. 243°), corresponding to reaction of naphthalene and phthalideneacetic acid with elimination of one mole of water. It is not cyclizable to the benzopyrenequinone even under rather drastic conditions. It is therefore not the *o*-(1-oxo-1H-benzonaphthen-3-yl) benzoic acid (VII), but rather one of the by-product benzindenones VIII or IX. Its structure was established as VIII (the benzindenonecarboxylic acid) by

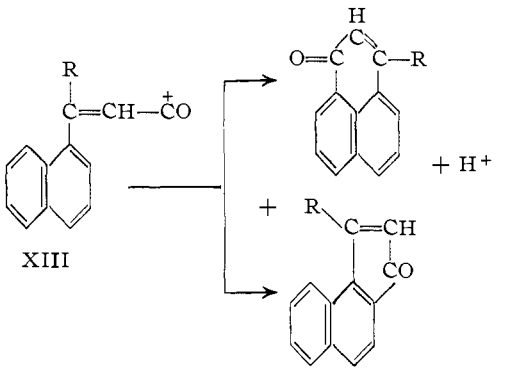


Oxidation of VIII with chromic acid yielded the dilactone $C_{19}H_{10}O_4$ (X). Treatment with hydrazine in diethylene glycol by the procedure of Huang-Minlon[6] did not effect the planned reduction of the naphthoylbenzoic acid but afforded instead

(6) Huang-Minlon, THIS JOURNAL, **68**, 2487 (1946).

the alkali-soluble phthalazine, $C_{19}H_{12}O_3N_2$ (XI), m.p. 322°. Decarboxylation proceeded smoothly to give the 1-naphthylphthalazine (XII) which was found identical with that obtainable from 2-(1-naphthoyl)-benzoic acid.

Since the phthalideneacetic acid condensation affords both quinone IV and the phenylbenzindenone VIII which is not convertible to the quinone, it can be assumed that the first step in the synthesis is a hydrogen fluoride *alkylation* of the naphthalene moiety in the α-position to form a complex represented by XIII, wherein the aliphatic carboxyl can now cyclize into either the *ortho* or peri positions.



The relative reaction rates naturally will depend upon the structures involved.

Experimental

Phthalideneacetic Acid.—The following procedure is an improvement over the original work of Gabriel and Michael.[1] A mixture of 600 g. of phthalic anhydride, 800 cc. of acetic anhydride and 400 g. of anhydrous potassium acetate was heated with stirring to 95° on the steam-bath. When the mass was fluid the steam-bath was replaced with an oil-bath heated to 160°. The temperature of the reaction mixture quickly rose to 140° whereupon the charge became dry and spongy. After 10 min. stirring it became fluid and after 1 hr. was cooled to 90–95° and treated with 2000 cc. of 70° water. After hot filtration the product was washed with water until the filtrates were light in color and then with alcohol and acetone in turn to remove red impurities. The yield of product, m.p. 325–328° (block), was 377 g. (49%). This product is of good quality but may be further purified to melt at 330° by recrystallization from pyridine or glacial acetic acid.

Condensation of Phthalideneacetic Acid with Naphthalene. 1. 3,4-Benzopyrene-1,5-quinone (Benzo[α]pyrene-6,12-dione).—Naphthalene (170 g., 1.32 moles) and phthalideneacetic acid (250 g., 1.3 moles) were charged into a one-gallon stainless steel autoclave equipped with stirrer and a blow leg suitable for eventual discharge of the reaction mass. The autoclave was sealed, tested at 300 lb. and then evacuated and cooled. Anhydrous (triple distilled) hydrogen fluoride (2100 g.) was then added from a weighed cylinder through copper tubing. The autoclave was then sealed, held at 8° for 2 hours and at 30–34° for 16 hr. with stirring. There was no noticeable evolution of heat when the charge was heated to 30°. The pressure developed initially was 17–20 p.s.i. and this gradually decreased to 9 p.s.i. during the course of the reaction. The reaction mixture was cooled to 0–3° and discharged by means of positive nitrogen pressure into ice-water with stirring. After filtration the product was washed acid-free and extracted with 100 g. of $NaHCO_3$ in 6000 cc. of water. The washed filter cake afforded 266 g. (72.5% based on phthalideneacetic acid) of crude benzopyrenequinone, m.p. 300–306°. Recrystallization from *o*-dichlorobenzene gave 223 g. (58%) of purified quinone, m.p. 324–326°.

The sublimed or further recrystallized material melts at 327° (block), gives a red solution in 96% H_2SO_4 and an orange solution in cold alkaline sodium dithionite from which the starting material is regenerated on air oxidation.

Anal. Calcd. for $C_{20}H_{10}O_2$: C, 85.00; H, 3.54. Found: C, 84.82; H, 3.54.

Zinc dust distillation in the usual manner afforded 3,4-benzopyrene (m.p. 177–178°, m.p. of trinitrobenzene complex 223–224°).

2. The Acidic By-product (3-Phenyl-3,4-benzinden-one-1,2′-carboxylic Acid).—The aqueous bicarbonate solution obtained above was clarified with charcoal and acidified to give 101 g. (25.7%) of bright yellow needles, m.p. 242.5°, after recrystallization from acetic acid. The compound is readily soluble in alkaline solutions and corresponds by analysis to the product from addition of phthalideneacetic acid to naphthalene without elimination of water.

Anal. Calcd. for $C_{20}H_{12}O_3$: C, 80.00; H, 4.00. Found: C, 80.05; H, 4.18.

Variations in Reaction Conditions.—The reactions are conveniently carried out in steel autoclaves or in small bombs. The condensation does not occur at temperatures as low as 0–2° in 16 hours. However, at 20–25° a 57% yield of crude quinone and a 41% yield of the by-product is obtained in a 16 hour reaction. As the conditions were made more vigorous (up to 80°), the same products were obtained in 48 and 30% yield but an increased amount of amorphous material resulted. Best results were obtained in the 25–45° region and involved reaction times of from 8 to 18 hr. In these cases yields of 50–55% of purified quinone and 30–45% of the benzindenonecarboxylic acid were obtained.

Condensation of Phthalideneacetic Acid with Aromatic Hydrocarbons.—The following results were obtained in a series of experiments wherein 1–10 g. of hydrocarbon and an equimolar amount of phthalideneacetic acid were heated in 10–15 parts of hydrogen fluoride in a 200 cc. steel bomb. The hydrocarbon was first loaded into the bomb which was evacuated and chilled to 0°. Anhydrous HF was then introduced from a weighed small cylinder through a short section of flexible copper tubing.

Hydrocarbon	% Vattable quinone	% Acid product
Naphthalene	55	40
1-Methylnaphthalene	Trace	5–10
2-Methylnaphthalene[a]	3–5	5–10
2,6-Dimethylnaphthalene	Trace	Trace
Anthracene at 40°[b]	0	95
Anthracene at 90°[c]	95	0
Fluoranthene (at 50°)[d]	5	..

[a] M.p. 285°, orange vat, red soln. in C.P. H_2SO_4. Calcd. for $C_{21}H_{12}O_2$: C, 85.15; H, 4.05. Found: C, 84.85; H, 4.29. [b] Orange m.p. 317° from addition anthracene to phthalideneacetic acid, mole per mole. Calcd. for $C_{24}H_{14}O_4$: C, 78.7; H, 3.83. Found: C, 78.71; H, 4.07. [c] Mixture of vattable prod. [d] M.p. 400°, deep red soln. in H_2SO_4.

Structure of By-product: 1-(*o*-Carboxyphenyl-3H-benz[e]indene-3-one. a. 4,5-Benzo-3,3′-spirobiphthalide.—The by-product (5 g.) was oxidized with 15 g. of CrO_3 in 100 ml. of glacial acetic acid at 25–100°. The solution was poured onto ice and the crystalline product filtered to yield 1.2 g. of crude material, which melted at 175–176° after recrystallization from ethanol. This product is soluble in warm aqueous NaOH but insoluble in either sodium bicarbonate or carbonate.

Anal. Calcd. for $C_{19}H_{10}O_4$: C, 75.45; H, 3.38. Found: C, 75.38; H, 3.48.

b. 1-(4-Hydroxy-1-phthalazinyl)-2-naphthoic Acid.—A solution of 1 g. of lactone in 10 ml. of diethylene glycol containing 0.6 g. of NaOH and 0.6 cc. of hydrazine hydrate was heated 1 hour in an open flask, allowing water and excess hydrazine to escape until the temperature reached 195°. After 3 hr. at reflux the solution was poured onto ice and the product filtered. The product was dissolved in dilute aqueous NaOH, clarified and reprecipitated with acid and this procedure repeated, yield 0.52 g. After recrystallization from acetone the product melted at 322°.

c. 4-(1-Naphthyl)-1-phthalazinol.—A mixture of CuO (5 g.) with the above phthalazinecarboxylic acid (1 g.) and quinoline (10 ml.) was heated at 200–230° until evolution of CO_2 had ceased. The slurry was poured into 100 cc. of 8 *N* HCl, extracted with benzene, washed, dried and de-

colorized. On concentration there was obtained 0.5 g. of the pyridazine, m.p. 260°.

Anal. Calcd. for $C_{18}H_{12}ON_2$: C, 79.41; H, 4.42; N, 10.33. Found: C, 79.45; H, 4.72; N, 10.93.

This phthalazine was found to be identical with an authentic sample of the phthalazine from 2-(1-naphthoyl)-benzoic acid (m.p. and mixed m.p.). Both products afforded 2-(1-naphthoyl)-benzoic acid on acid hydrolysis.

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

The Synthesis and Resolution of 1,12-Dimethylbenzo[c]phenanthrene-5-acetic Acid[1]

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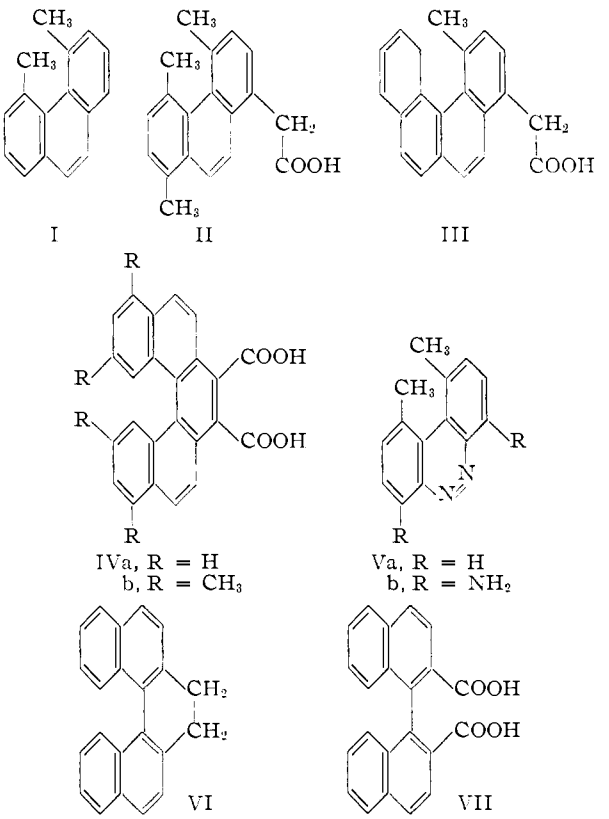
The synthesis and resolution of 1,12-dimethylbenzo[c]-phenanthrene-5-acetic acid (XIX) are described. The optical stability of the enantiomorphic forms of XIX is greater than that for any compounds yet synthesized which owe their optical activity to intramolecular overcrowding. Racemization occurs only at temperatures (*ca.* 250°) at which decomposition begins.

It was predicted[2] in 1940 that molecules containing the 4,5-dimethylphenanthrene system, I, might be capable of optical resolution due to the effect of the interference of the methyl groups in the hindered positions. Three alternatives were suggested relative to the geometry of the molecule as a whole in this system[2]: "(1) the methyl groups lie bent away from each other but in the same plane as the aromatic rings; (2) the aromatic rings are distorted in some way; (3) the methyl groups are bent out of the plane of the aromatic rings." If the first alternative were correct, there would be no asymmetry and the molecule would not be resolvable. However, if the second or third alternative, or a combination of the two, were correct, the molecule would be capable of resolution.

That (2) or (3) is the correct explanation has been shown by the successful resolution of 4,5,8-trimethyl-1-phenanthrylacetic acid (II),[3] 4-(1-methylbenzo[c]phenanthryl)-acetic acid (III)[4] and 4′,4″,6′,6″ - tetramethyl - 3,4,5,6 - dibenzphenanthrene-9,10-dicarboxylic acid (IVb).[5] Although the nitrogen-containing compound, 1,10-dimethylbenzo[c]cinnoline (Va), could not be resolved,[6,7] the corresponding 4,7-diamino-1,10-dimethylbenzo-[c]cinnoline (Vb) was resolved.[3] Other compounds showing this type of optical activity[9] and containing no methyl groups also have been synthesized and resolved; *e.g.*, 3,4,5,6-dibenzphenanthrene-9,10-dicarboxylic acid (IVa)[10] and 9,10-dihydro-3,4,5,6-dibenzphenanthrene (VI),[11] which was prepared from optically active 1,1′-dinaphthyl-2,2′-dicarboxylic acid (VII).



Compound VI is an example of a molecule which bridges the gap between the biphenyl type and the intramolecular overcrowding type of optical activity.

The recent X-ray crystallographic investigation of the structures of overcrowded aromatic compounds by Schmidt and co-workers[12–15] has clari-

(1) The material herein presented is taken from the Ph.D. thesis of R. M. Wise, Ohio State, 1955. Allied Chemical and Dye Fellow, 1952–1953. This work was also supported in part by a grant from the Office of Ordnance Research and Development, contract DA-33-019-ord-1240.

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