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

The Synthesis of 3′,6-Dimethyl-1,2-benzanthracene[1]

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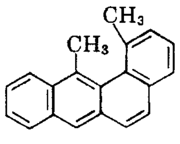
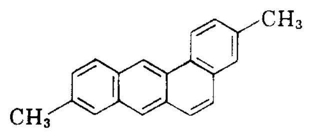
The synthesis of 3′,6-dimethyl-1,2-benzanthracene (II) from 4,4′-dimethyldesoxybenzoin (III) as shown in the chart is described.

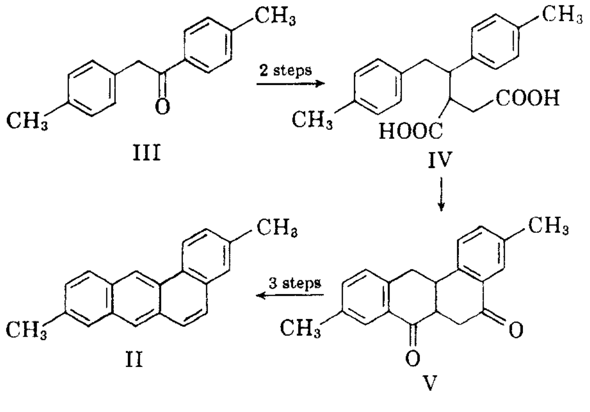
One method of measuring the strain involved in intramolecularly overcrowded molecules involves accurate measurement of the heats of combustion of two isomeric compounds, one overcrowded and the other not. To measure the strain in 1′,9-dimethyl-1,2-benzanthracene[3] (I) due to the hindrance of the adjacent methyl groups, it was necessary to have a dimethyl-1,2-benzanthracene in which there was no *ortho* substituent to either methyl group. We now report on the synthesis of 3′,6-dimethyl-1,2-benzanthracene[4] (II) by a 1,2-benzanthracene synthesis developed in this Laboratory.[5] The steps are outlined in the chart.



I



II



The starting ketone, 4,4′-dimethyldesoxybenzoin (III) was prepared in 81% yield by condensation of *p*-methylbenzylmagnesium chloride with *p*-tolunitrile. Condensation of *p*-tolylmagnesium bromide with *p*-methylphenylacetonitrile afforded III in only 24% yield. Modified Stobbe condensation[6] of III with dimethyl succinate, followed by alkaline hydrolysis of the acid mixture afforded a pure unsaturated dibasic acid which on hydrogenation yielded a mixture of the saturated substituted succinic acids, IV in high yield. In further work, only the higher melting more abundant isomer was used. Cyclization of IV by anhydrous hydrogen fluoride yielded a mixture of diketones (V) of which again only the higher melting more abundant isomer was used. Interestingly, the yields of diketones in the present case (64–69%) were considerably greater than those in the case of the nonmethylated analog.[5] Reduction of the diketone (V) to a mixture of diols (not separated), dehydration of these and dehydrogenation of the dehydration mixture by heating with sulfur yielded pure 3′,6-dimethyl-1,2-benzanthracene (II) in 70–80% over-all yield from V. Over twenty grams of pure II was made and samples of I and II have been sent to Dr. J. Margrave, University of Wisconsin, for determination of the heats of combustion.

EXPERIMENTAL[7]

p-Methylbenzyl chloride.[8] To a solution of 0.6 g. of benzoyl peroxide in 1062 g. of *p*-xylene[9] at reflux was added 675 g. of freshly distilled sulfuryl chloride during 2 hr. At the end of this time 0.6 g. of benzoyl peroxide in 50 ml. of xylene was added and reflux continued for 3 hr. The cooled mixture was washed well with water, dried over magnesium sulfate, and fractionally distilled to yield 526 g. (75%) of crude *p*-methylbenzyl chloride, b.p. 85–95° at 2–3 mm. Further fractionation through a wide 2-ft. high column packed with $^3/_{16}$-in. glass beads yielded 452 g. (64%) of product, b.p. 48–50° at about 1 mm., n_D^{17} 1.5360.

p-Tolunitrile. A mixture of 85.5 g. of pure *p*-bromotoluene, 67 g. of cuprous cyanide, and 100 ml. of *N*-methylpyrroli-

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(1) This research was supported by grant G 9482 of the National Science Foundation.

(2) To whom inquiries should be addressed.

(3) M. S. Newman, W. C. Sagar, and M. V. George, *J. Am. Chem. Soc.*, **82**, 2376 (1960).

(4) The synthesis of II, m.p. 186–187°, by a different route has been reported: J. W. Cook, *J. Chem. Soc.*, 456 (1932).

(5) M. S. Newman and R. T. Hart, *J. Am. Chem. Soc.*, **99**, 298 (1947).

(6) W. S. Johnson and V. L. Stromberg, *J. Am. Chem. Soc.*, **72**, 505 (1950).

(7) All melting points are uncorrected. The term "worked up in the usual way" means that an ether-benzene solution of the reaction products was washed with acid and/or alkali as indicated, and with a saturated solution of sodium chloride and filtered through a bed of anhydrous magnesium sulfate. Solvents were then removed by distillation. In most cases the yields cited are not maximal as emphasis was placed on obtaining pure intermediates. Analyses by Galbraith Analytical Laboratories, Knoxville, Tenn., and by the Schwarzkopf Laboratories, New York, N. Y.

(8) This compound is now available from the Diamond Alkali Co., Painesville, Ohio.

(9) Eastman *p*-xylene was distilled through a 2-ft. packed column, the fraction, b.p. 139.5–140.5°, being used.

done[10] (NMP) was held at reflux for 2 hr. Work-up as described[11] and fractionation yielded *p*-tolunitrile, b.p. 54.5–56.5° at 1–2 mm., n_D^{23} 1.5289, in 95% yield.

4,4′-Dimethyldesoxybenzoin (III). To 475 ml. of 0.96*M* *p*-methylbenzylmagnesium chloride[12] in ether was added a solution of 39.4 g. of *p*-tolunitrile in 50 ml. of ether during 15 min. After refluxing for 12 hr., the ether was displaced by 300 ml. of xylene and refluxing continued for 3 hr. On cooling the mixture was poured on ice and 100 ml. of concd. hydrochloric acid. The crystalline ketimine hydrochloride was collected and mixed with the aqueous acid solution. This mixture was refluxed for 1 hr. The colorless solid which separated on cooling weighed 61 g. (91%) and was good material. Recrystallization. from absolute alcohol yielded pure III,[13] m.p. 102.5–103.5°, in 82% yield. When *p*-tolylmagnesium bromide was added to *p*-methylphenylacetonitrile in ether and the reaction mixture (in toluene) was refluxed for 3 hr., the yield of III was only 24%. When a solution of 0.75 mole of *p*-methylphenylacetyl chloride in 150 ml. of toluene was added to a stirred mixture of 0.85 mole of aluminum chloride in 100 ml. of toluene at 45–50° during 1 hr. and the mixture was held at 50° for 1 hr., the yield of pure III was 77%.

3-Carboxy-4,5-di-p-tolylpentanoic acid (IV). In a typical run, a solution made by dissolving 98 g. of potassium in 1.75 l. of dry *t*-butyl alcohol and then adding 511 g. of dimethyl succinate was added during 4 hr. to a stirred solution of 337 g. of pure III in 500 ml. of *t*-butyl alcohol held at 85–90°. After 1 hr. at this temperature the cooled mixture was acidified with 2*N* hydrochloric acid. After removal of most of the *t*-butyl alcohol under reduced pressure an alkaline extract of the reaction products was refluxed for 2 hr. After acidification and the usual work-up,[4] crystallization from alcohol-benzene yielded 182 g. (37%) of 3-carboxy-4,5-di-*p*-tolyl-4-pentenoic acid, m.p. 196–198° dec.

Anal. Calcd. for $C_{20}H_{20}O_4$: C, 74.1; H, 6.2. Found: C, 73.9, 74.1; H, 6.2, 6.4.

From the mother liquors by repeated crystallization from alcohol-benzene was obtained 105 g. (22%) of the same acid, m.p. 195–198° dec. Another lower melting isomer was present but no attempt was made to obtain it pure. In further work only the pure acid was used.

On catalytic hydrogenation at 40–50 p.s.i. over platinum in absolute alcohol (150 ml.), 35.7 g. of the above acid was reduced in 4 hr. to yield a mixture of isomers of IV, m.p. 189–197°, in 75% yield. Pure IV, m.p. 198–200° dec, was obtained on two crystallizations from ethyl acetate. Mixed melting points with the unsaturated acid, m.p. 196–198° were in the 183–188° range.

Anal. Calcd. for $C_{20}H_{22}O_4$: C, 73.6; H, 6.8. Found: C, 73.5, 73.6; H, 6.7, 6.8.

3′,6-Dimethyl-3,4,4a,9,9a,10-hexahydro-1,2-benzanthracene-3,10-dione (V). A solution of 32.6 g. of IV in 300 ml. of anhydrous hydrogen fluoride was allowed to stand for 48 hr. until most of the hydrogen fluoride had evaporated. The crude material was washed with sodium bicarbonate solution to remove acidic fractions. A high-melting solid, m.p. 248–251°, remained after repeated extractions of the neutral products with hot benzene. From the benzene extracts a lower-melting isomer, m.p. 180–184°, was isolated. The yield of diketones (V) was about 69%. Recrystallization of the higher and lower melting isomers of V from tetrahydrofuran yielded the forms, m.p. 249–251° and 192.5–193.5°.

Anal. Calcd. for $C_{20}H_{18}O_2$: C, 82.8; H, 6.3. Found: 251° isomer: C, 82.6, 82.8; H, 6.5, 6.4. 193° isomer: C, 83.0, 83.0; H, 6.2, 6.3.

In five runs involving 222 g. of IV, 91 g. of 251° isomer and 35 g. of 193° isomer were obtained (over-all yield, 64%).

3′,6-Dimethyl-1,2-benzanthracene (II). A solution of 58.1 g. of the isomers of V in 2 l. of dry tetrahydrofuran was added during 1 hr. to a refluxing solution of 11.4 g. of lithium aluminum hydride in 100 ml. of tetrahydrofuran, and the mixture was refluxed for 12 hr. After distillation of most of the tetrahydrofuran, the residue was treated with moist ether and then dilute sulfuric acid. The colorless solid, 40.5 g. (69%), m.p. 153–156°, was collected by filtration and the organic layer separated and worked up in the usual way[7] to yield 6.1 g. (10%) of diol, m.p. 190–208°, and 8.7 g. (15%) of diol, m.p. 154–166°. For further work all of these fractions of diol could be used. Recrystallization of the high-melting fraction from ethyl acetate yielded colorless feathery crystals, m.p. 192–210°.

Anal. Calcd. for $C_{20}H_{22}O_2$: C, 81.6; H, 7.5. Found: C, 81.7; H, 7.7.

A mixture of 47.4 g. of mixed diols in 300 ml. of xylene containing 50 mg. of iodine was refluxed for 45 hr. On work ing up the reaction mixture as usual, 41.4 g. of crude dehydration product, m.p. 126–159°, was obtained. Recrystallization of a portion from benzene yielded colorless platelets, m.p. 160.5–162.5°, of a dihydro-3′,6-dimethyl-1,2-benzanthracene.

Anal. Calcd. for $C_{20}H_{18}$: C, 93.0; H, 7.0. Found: C, 92.9; H, 7.0.

A mixture of 25.8 g. of the above diol mixture, m.p. 126–159°, and 3.21 g. of sulfur was heated at 195° for 1 hr. A small amount of zinc dust was added and heating continued for 5 min. The product was taken into benzene and chromatographed over alumina to yield 23.2 g. (91%) of II, m.p. 185–186.5°. Vacuum distillation and further chromatography yielded 3′,9-dimethyl-1,2-benzanthracene as colorless shiny platelets, m.p. 187.5–188.5° (20.7 g., 81%). Recrystallization of a small amount yielded a pure sample,[4] m.p. 188.0–189.0°.

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(10) We acknowledge with thanks the gift of a generous supply of *N*-methylpyrrolidone from the Antara Chemicals division of General Aniline and Film Corp.

(11) M. S. Newman and H. Boden, *J. Org. Chem.*, **26**, 0000 (1961).

(12) Acid-titrated as described by H. Gilman *et al.*, *J. Am. Chem. Soc.*, **45**, 150 (1923); yield 91%.

(13) A m.p. of 102° has been reported by R. Stierlin, *Ber.*, **22**, 376 (1889), whereas Buü-Hoi, Nguyen-Hoan, and R. Royer, *Bull. soc. chem. France*, [5] **14**, 84 (1947) report 87°.