118. *Some Isomeric Amido- and Amino-derivatives of 9-Methyl- and 9,10-Dimethyl-anthracene.*

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The preparation and stereochemistry of some 9,10-dihydro-9-methyl- and 9,10-dihydro-9,10-dimethyl-anthracene derivatives (9,10-dicarboxylic acid and their amides and esters) are reported.

DURING our work on *meso*-substituted dihydroanthracenes with potential analgesic activity, the compounds (I; $R, R' = H$ or Me; $R'' = CH_2OH$ or $CH_2{\cdot}CO_2Alk$; $R''' = CH_2Y$) were required in which Y is a basic group present in known analgesics, *e.g.*, morpolino or dimethylamino. The preparation of such compounds in which $R = R' = H$ has been reported elsewhere.[1]

Dimethylanthracene Series (I; $R = R' = Me$).—*cis*- and *trans*-9,10-Dihydro-9,10-dihydroxy-9,10-dimethylanthracene were isolated from the ether-soluble and the ether-insoluble fraction respectively obtained by reaction of methylmagnesium iodide with anthraquinone. The infrared spectra of chloroform solutions of the isomers showed

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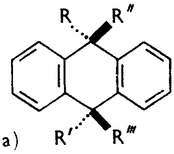
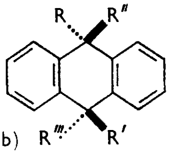
[1] Beckett and Mulley, *J.*, 1955, 4159.

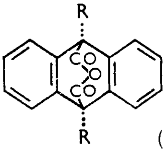
differences that could not all be attributed to the solvent of crystallisation of the *trans*-isomer. The infrared spectrum of the *cis*-isomer in chloroform solution was identical with that of the *cis*-diol prepared stereospecifically by reducing 9,10-epidioxy-9,10-dimethylanthracene [2] with lithium aluminium hydride.

(Ia)

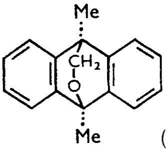


(Ib)





(II)



(III)

The isomers gave the same dimethyl ether (I; $R = R' = Me$, $R'' = R''' = OMe$) on treatment with mineral acid in methanol–benzene; [3] a similar result was apparently obtained by Pinazzi on etherification of *cis*- and *trans*-9,10-dihydro-9,10-dihydroxy-9,10-diphenylanthracene.[4] Intermediate carbonium-ion formation would permit the sterically more favoured dimethyl ether to be formed from either diol.

Treatment of 9,10-dihydro-9,10-dimethoxy-9,10-dimethylanthracene with sodium in ether, followed by carboxylation, gave essentially pure dicarboxylic acid, in contrast to the mixture of mono- and di-carboxylic acids resulting from similar treatment of anthracene or 9-methylanthracene.[5] Isolation of the *cis*-dicarboxylic acid (Ia; $R = R' = Me$, $R'' = R''' = CO_2H$) before dehydration improved the previous yield [6] of the anhydride (II; $R = R' = Me$). The anhydride was converted into the *cis*-morpholide acid * (Ia; $R = R' = Me$, $R'' = CO_2H$, $R''' = CO{\cdot}NC_4H_8O$) by boiling morpholine.[7] This gave a methyl ester that with lithium aluminium hydride yielded the alcohol (Ia or b; $R = R' = Me$, $R'' = CH_2{\cdot}OH$, $R''' = H$) by an unusual type of hydrogenolysis. With this reagent the *cis*-dimethylamide ester (Ia; $R = R' = Me$, $R'' = CO_2Me$, $R''' = CO{\cdot}NMe_2$) gave a small amount of the expected dimethylaminomethyl derivative ($R''' = CH_2{\cdot}NMe_2$) but chiefly lost the amide group to give the alcohol (I; $R = R' = Me$, $R'' = CH_2{\cdot}OH$, $R''' = H$); a compound to which the provisional formula (III) has been assigned was also isolated in small yield.

Since hydrogenolyses with lithium aluminium hydride of amides to aldehydes occur more readily with tertiary than with primary amides,[8] the primary amide ester (Ia; $R = R' = Me$, $R'' = CO_2Me$, $R''' = CO{\cdot}NH_2$) was prepared by treatment of the anhydride (II; $R = R' = Me$) with aqueous ammonia and esterification of the product with diazomethane. The *cis*-amide ester was reduced with lithium aluminium hydride, giving a good yield of the amino-alcohol (Ia; $R = R' = Me$, $R'' = CH_2{\cdot}OH$, $R''' = CH_2{\cdot}NH_2$), which with formaldehyde–formic acid gave the desired *cis*-dimethylamino-alcohol ($R''' = CH_2{\cdot}NMe_2$). Since this dimethylamino-alcohol was recovered unchanged after treatment under conditions which caused hydrogenolysis of the *cis*-dimethylamide ester (Ia; $R = R' = Me$, $R'' = CO_2Me$, $R''' = CO{\cdot}NMe_2$), this base is probably not an intermediate in the hydrogenolysis.

9-*Methylanthracene Series* (I; $R = Me$, $R' = H$).—Immediate acidification after dissolution of 9,10-dihydro-9-methylanthracene-*cis*-9,10-dicarboxylic anhydride [6] (II; $R = Me$, $R' = H$) in boiling 10% sodium hydroxide solution yielded the substantially pure *cis*-diacid. Acidification after the alkaline solution had been boiled for 3 hours gave

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* In this and similar cases throughout this paper a prefix *cis* or *trans* refers to the relation of the carboxyl groups or modified carboxyl groups to one another.

[2] Willemart, *Bull. Soc. chim.*, 1938, **5**, 556.

[3] Bachmann and Chemerda, *J. Org. Chem.*, 1939, **4**, 583.

[4] Pinazzi, *Compt. rend.*, 1946, **223**, 1150.

[5] Beckett and Lingard, *J.*, 1959, 2409.

[6] Beckett, Lingard, and Mulley, *J.*, 1953, 3328.

[7] Mulley, Thesis, London, 1955.

[8] Gaylord, " Reduction with Complex Metal Hydrides," Interscience Publ. Inc., New York, 1956, Chapter 10.

the pure *trans*-diacid which yielded less of the *cis*-anhydride when heated with acetic anhydride. The isomeric acids gave the corresponding dimethyl esters with diazomethane.

The *cis*-dicarboxylic anhydride[6] (II; R = R′ = H) dissolved in cold aqueous morpholine to give the known *cis*-acid amide[1] (Ia; R = R′ = H, R″ = CO_2H, R‴ = $CO{\cdot}NC_4H_8O$) almost quantitatively. Under similar conditions, 9,10-dihydro-9-methylanthracene-*cis*-9,10-dicarboxylic anhydride (II; R = Me, R′ = H) gave a substantially pure morpholide acid which was allocated the *cis*-amide acid configuration (Ia; R = Me, and R′ = H, or *vice versa*; R″ = CO_2H, R‴ = $CO{\cdot}NC_4H_8O$) because slower inversion of configuration under alkaline conditions would be expected for this compound than for the morpholide acid (Ia) where R = R′ = H. Reduction of the methyl ester (isomer A) (Ia; R = Me, R′ = H, R″ = CO_2Me, R‴ = $CO{\cdot}NC_4H_8O$) with lithium aluminium hydride gave the amino-alcohol (R″ = $CH_2{\cdot}OH$) in good yield, which supports the configuration assigned to the amide acid.

Treating the anhydride (II; R = Me, R′ = H) with acid in methanol yielded one of the two possible *cis*-acid esters; this gave the *cis*-dimethyl ester (see above) on treatment with diazomethane. The *cis*-acid ester was converted (by treatment with purified thionyl chloride under mild conditions)[9] into the ester acid chloride, and this with morpholine in ether gave one, stereochemically almost pure morpholide ester (isomer B). Since this isomer is probably a *cis*-morpholide ester[1] and had an infrared spectrum in chloroform solution which differed from that of its isomer A, it appears that treatment of the *cis*-dicarboxylic anhydride with either aqueous morpholine or acid methanol gives the 9-carboxylic acid in both cases. As an unsymmetrical aliphatic anhydride gives in major yield that isomer which has the acidic group adjacent to the more branched α-carbon atom,[10] the structures can be deduced with some certainty. Moreover, the anhydride would be expected to undergo preferential nucleophilic attack at the carbon atom of the carbonyl group attached to the CH, owing to the +*I* effect of the methyl group. The isomeric morpholide esters A and B are therefore assigned the structures (Ia; R = Me, R′ = H) in which R″ = CO_2Me, R‴ = $CO{\cdot}NC_4H_8O$ and R″ = $CO{\cdot}NC_4H_8O$, R‴ = CO_2Me, respectively. Reduction of isomer B with lithium aluminium hydride, in contrast with the similar reduction of the *cis*-morpholide ester where R = R′ = Me, gave a substantial yield of crude base, also supporting[1] the assignment of the *cis*-morpholide ester configuration; the pure morpholide alcohol (Ia; R = Me, R′ = H, R″ = $CH_2{\cdot}NC_4H_8O$, R‴ = $CH_2{\cdot}OH$) could be isolated only in rather low yield.

EXPERIMENTAL

cis- *and* trans-9,10-*Dihydro*-9,10-*dihydroxy*-9,10-*dimethylanthracene* (I; R = R′ = Me, R″ = R‴ = OH).—Anthraquinone (50 g.), suspended in dry ether (500 ml.), was added to methylmagnesium iodide [from magnesium (48 g.) and methyl iodide (125 ml.)] in ether (500 ml.), and the mixture was heated under reflux for 1 hr. The product was added to crushed ice (1 kg.) and ammonium chloride (150 g.) to give a white solid which was shaken with 10% aqueous acetic acid (2 × 1 l.). Crystallisation from benzene gave *trans*-9,10-dihydro-9,10-dihydroxy-9,10-dimethylanthracene monohydrate (from which the water could not be removed by azeotropic distillation with benzene) as plates, m. p. 192—193° (Found: C, 74·8; H, 6·8. Calc. for $C_{16}H_{16}O_2,H_2O$: C, 74·4; H, 7·0%). Crystallisation of this *trans*-diol from methanol–benzene gave a white solid, m. p. 188°, from which all the methanol could not be removed by azeotropic distillation with benzene (Found: C, 76·7; H, 6·9. Calc. for $C_{16}H_{16}O_2,\frac{1}{2}CH_3{\cdot}OH$: C, 77·3; H, 7·1%).

Evaporation of the ethereal mother-liquors of the reaction gave crystals (20·8 g.) which

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[9] Chase and Hey, *J.*, 1952, 553.

[10] Newman, "Steric Effects in Organic Chemistry," John Wiley and Sons, Inc., New York, 1956, p. 228.

recrystallised from methanol–benzene (1 : 1) to give a solid from which any methanol was removed by azeotropic distillation with benzene; thus was obtained *cis*-9,10-dihydro-9,10-dihydroxy-9,10-dimethylanthracene as plates, m. p. and mixed m. p. 189° (Found: C, 79·8; H, 6·7. Calc. for $C_{16}H_{16}O_2$: C, 80·0; H, 6·7%). The infrared spectrum in $CHCl_3$ solution was identical with that of the authentic diol.

9,10-*Dihydro*-9,10-*dimethoxy*-9,10-*dimethylanthracene* (I; R = R′ = Me, R″ = R‴ = OMe).—(a) *From* trans-9,10-*dihydro*-9,10-*dihydroxy*-9,10-*dimethylanthracene.* Concentrated hydrochloric acid (0·02 ml.) was added to the *trans*-diol (0·200 g.) in 1 : 1 methanol–benzene (5 ml.) and after ½ hr., the solution was washed with water and evaporated to give a solid; this crystallised from 1 : 1 methanol–benzene (1·5 ml.) to give 9,10-dihydro-9,10-dimethoxy-9,10-dimethylanthracene (0·106 g.) as plates, m. p. 198—199° (Bachmann[3] reported m. p. 197°). (b) *From* cis-9,10-*dihydro*-9,10-*dihydroxy*-9,10-*dimethylanthracene.* The *cis*-diol (0·200 g.) was treated as above and gave 9,10-dimethoxy-9,10-dimethylanthracene (0·177 g.) as plates, m. p. 198—199° alone or mixed with the diether from the *trans*-diol. In later preparations of the diether, the crude ether-soluble and ether-insoluble diol fractions were used, and gave 75—85% of the required product.

cis-9,10-*Dihydro*-9,10-*dimethylanthracene*-9,10-*dicarboxylic Acid* (Id; R = R′ = Me, R″ = R‴ = CO_2H).—9,10-Dihydro-9,10-dimethoxy-9,10-dimethylanthracene (15 g.), sodium shot (15 g.), and glass chips in dry ether (450 ml.) were shaken for 1 week. After 24 hr., the solution had changed from colourless to greenish-yellow and, after further shaking overnight, had become greenish-black. The product was run into a slurry of solid carbon dioxide in dry ether (500 ml.) and left overnight. Water was added and the aqueous layer was acidified and extracted with ethyl acetate to yield crude 9,10-dihydro-9,10-dimethylanthracene-9,10-dicarboxylic acids (14·3 g., 86%) as a light yellow powder (Found: equiv., 146. Calc. for $C_{18}H_{16}O_4$: equiv., 148). In later preparations, the acids were filtered off from the acidified aqueous layer. Crystallisation from dimethylformamide or elution chromatography with methanol on granular gas-absorption charcoal gave *cis*-9,10-dihydro-9,10-dimethylanthracene-9,10-dicarboxylic acid[1] (50—65%), m. p. and mixed m. p. 310—312°.

cis-9,10-*Dihydro*-9,10-*dimethylanthracene*-9,10-*dicarboxylic Anhydride* (II; R = R′ = Me).—*cis*-9,10-Dihydro-9,10-dimethylanthracene-9,10-dicarboxylic acid (5 g.) was heated in acetic anhydride (10 ml.) for 10 min. Evaporation of the solvent to small volume gave the anhydride[6] (2·3 g., 49%) as cubes, m. p. 220—221°.

cis-9,10-*Dihydro*-9,10-*dimethylanthracene*-9,10-*dicarboxylic Acid Morpholide* (Ia; R = R′ = Me, R″ = CO_2H, R‴ = $CO{\cdot}NC_4H_8O$).—The anhydride (2·4 g.) was treated with morpholine as previously described, and gave the *cis*-monomorpholide[7] (3·0 g., 95%), m. p. 290—291°. Treatment with diazomethane in ether gave the morpholide methyl ester[1] (3·1 g., 100%), m. p. 155—157°.

9,10-*Dihydro*-9-*hydroxymethyl*-9,10-*dimethylanthracene* (Ia or b; R = R′ = Me, R″ = $CH_2{\cdot}OH$, R‴ = H).—The foregoing ester morpholide (1·3 g.) and an excess of lithium aluminium hydride were heated in ether under reflux for 6 hr. Sufficient water was added to give a white, granular precipitate, which was filtered off and extracted with ether and benzene. The combined organic solutions were extracted with 10% hydrochloric acid, but no basic material was obtained from the aqueous layer. Evaporation of the washed organic layer and crystallisation of the residue from benzene–light petroleum (b. p. 60—80°) gave 9,10-*dihydro*-9-*hydroxymethyl*-9,10-*dimethylanthracene* (0·5 g., 63%) as rhombs, m. p. 101—101·5° (Found: C, 85·4; H, 7·4. $C_{17}H_{18}O$ requires C, 85·7; H, 7·6%). A solution of the alcohol (0·10 g.) in dry pyridine (10 ml.) containing acetic anhydride (0·5 ml.) was shaken overnight. The product was poured into water (stirring), left for 5 hr. with occasional stirring, and filtered. Crystallisation of the residue (0·10 g.; m. p. 104—105°) from light petroleum (b. p. 60—80°) gave the *acetate* as needles, m. p. 105—106° (Found: C, 80·6; H, 6·9. $C_{19}H_{20}O_2$ requires C, 81·4; H, 7·2%).

cis-9,10-*Dihydro*-9,10-*dimethylanthracene*-9,10-*dicarboxylic Acid Dimethylamide* (Ia; R = R′ = Me, R″ = CO_2H, R‴ = $CO{\cdot}NMe_2$).—The powdered anhydride (2·7 g.) was dissolved in 20% aqueous dimethylamine (20 ml.). Slow acidification with concentrated hydrochloric acid precipitated a solid (2·9 g.), m. p. 285°, which crystallised from dibutyl ether to give the *acid dimethylamide* as cubes, m. p. 288—289° (Found: C, 74·1; H, 6·5; N, 4·5%; equiv., 323. $C_{20}H_{21}NO_3$ requires C, 74·3; H, 6·6; N, 4·3%; equiv., 323). Treatment with diazomethane in alcohol–ether and crystallisation from ethanol gave the *methyl ester amide* (2·4 g., 88%) as rhombs, m. p. 222—223° (Found: C, 75·1; H, 7·1; N, 3·9. $C_{21}H_{23}NO_3$ requires C, 74·8; H, 6·9; N, 4·2%).

Reduction (*with Lithium Aluminium Hydride*) *of the Foregoing Ester Dimethylamide*.—The *cis*-ester amide (2·4 g.) and an excess of lithium aluminium hydride were heated in dry ether for 6 hr. Sufficient water was added to give a white, granular precipitate which was filtered off and washed with ether; the combined ether solutions were extracted with 10% hydrochloric acid. The aqueous solutions were made alkaline with 10% sodium hydroxide solution and extracted with ether to give impure *cis*-10-dimethylaminomethyl-9,10-dihydro-9 hydroxymethyl-9,10-dimethylanthracene (0·13 g.) as needles, m. p. and mixed m. p. 115° (Found: equiv., 305. Calc. for $C_{20}H_{25}NO$: equiv., 295).

Evaporation of the acid-washed ether solution, fractional crystallisation of the residue from light petroleum (b. p. 60—80°), and hand-picking of the crystals gave 9,10-dihydro-9-hydroxymethyl-9,10-dimethylanthracene, m. p. and mixed m. p. 100°, and a compound which was thought to be 9,10-*endo*methyleneoxy-9,10-dihydro-9,10-dimethylanthracene, as tufts of colourless blades, m. p. 128—129° (Found: C, 85·9; H, 6·6. $C_{17}H_{16}O$ requires C, 86·4; H, 6·8%).

cis-9,10-*Dihydro*-9,10-*dimethylanthracene*-9,10-*dicarboxylic Acid Monoamide* (Ia; R = R′ = Me, R″ = CO_2Me, R‴ = $CO{\cdot}NH_2$).—The powdered anhydride (1·8 g.) was dissolved in 10% aqueous ammonia (50 ml.) and acidified with concentrated hydrochloric acid to give a white solid (1·9 g.), m. p. 268—269°. Crystallisation of this from 2-methoxyethanol gave the *monoamide* having the above m. p. (Found: C, 73·3; H, 6·0; N, 4·8. $C_{18}H_{17}NO_3$ requires C, 73·2; H, 5·8; N, 4·7%). Treatment with diazomethane in ether gave the *methyl ester amide* as needles (from ethanol), m. p. 240—241° (Found: C, 73·5; H, 6·1; N, 4·5. $C_{19}H_{19}NO_3$ requires C, 73·8; H, 6·2; N, 4·5%).

cis-9-*Aminomethyl*-9,10-*dihydro*-10-*hydroxymethyl*-9,10-*dimethylanthracene* (Ia; R = R′ = Me, R″ = $CH_2{\cdot}OH$, R‴ = $CH_2{\cdot}NH_2$).—The ester amide (1·2 g.) and an excess of lithium aluminium hydride were heated in ether for 6 hr. and the product (A) precipitated on treatment with water was extracted as before. Evaporation of the ether gave only a trace of solid. The combined aqueous extracts were made alkaline with 10% sodium hydroxide solution and extracted with ether, which removed a white crystalline material (B) (0·11 g.), m. p. 213°. The precipitate (A) was extracted with chloroform; evaporation of this extract gave a solid (0·72 g.), m. p. 220°, which, crystallised from benzene, gave the cis-*amino-alcohol* as rosettes, m. p. 221° (Found: C, 80·9; H, 8·1; N, 4·9. $C_{18}H_{21}ON$ requires C, 80·9; H, 7·9; N, 5·2%), identical with material (B).

cis-9-*Dimethylaminomethyl*-9,10-*dihydro*-10-*hydroxymethyl*-9,10-*dimethylanthracene* (Ia; R = R′ = Me, R″ = $CH_2{\cdot}OH$, R‴ = $CH_2{\cdot}NMe_2$).—The preceding amino-alcohol (0·87 g.) was heated with 90% formic acid (0·7 ml.) and 40% aqueous formaldehyde (0·6 ml.) for 20 hr. Excess of 10% sodium hydroxide solution was added and the resultant precipitate (0·95 g.; m. p. 117°) recrystallised from light petroleum (b. p. 60—80°)–benzene to give the cis-*dimethylamino-alcohol* (0·8 g., 83%) as blades, m. p. 119° (Found: C, 80·8; H, 8·3; N, 4·9%; equiv., 295. $C_{20}H_{25}NO$ requires C, 81·3; H, 8·5; N, 4·7%; equiv., 295).

When this base (1·2 g.) and excess of lithium aluminium hydride were heated together in ether for 6 hr. 92% (1·1 g.) of the base was recovered.

The amino-alcohol (0·4 g.) and acetic anhydride (0·2 ml.) in pyridine (5 ml.) overnight gave the O-*acetate* (0·32 g., 70%) as needles (from hexane), m. p. 62—63° (Found: C, 78·4; H, 8·0; N, 4·1. $C_{22}H_{27}NO_2$ requires C, 78·3; H, 8·1; N, 4·2%).

9,10-*Dihydro*-9-*methylanthracene*-cis-9,10-*dicarboxylic Acid* (Ia; R = Me, R′ = H, R″ = R‴ = CO_2H).—Powdered 9,10-dihydro-9-methylanthracene-9,10-*cis*-dicarboxylic anhydride (1·0 g.) was rapidly dissolved in boiling 10% sodium hydroxide solution (10 ml.), and the solution immediately cooled and acidified with concentrated hydrochloric acid. This precipitated a solid (1·0 g.), m. p. 258—260° (re-solidified and melted at 294—297°), which crystallised from glacial acetic acid to give the cis-*diacid* as rhombs, m. p. 262° (re-solidified and melted at 293°) (Found: C, 72·2; H, 5·0%; equiv., 141. $C_{17}H_{14}O_4$ requires C, 72·3; H, 5·0%; equiv., 141).

9,10-*Dihydro*-9-*methylanthracene*-trans-9,10-*dicarboxylic Acid* (Ib; R = Me, R′ = H, R″ = R‴ = CO_2H).—The 9-methyl-*cis*-dicarboxylic anhydride (0·5 g.) was heated with 10% sodium hydroxide solution (5 ml.) for 3 hr. Then acidification as above precipitated a white solid, the trans-*diacid* (0·51 g.), m. p. 308—309° (from acetic acid) (Found: C, 72·4; H, 4·8%; equiv., 140). When the anhydride was heated with the alkali for ½ hr., a mixture of the *cis*- and the *trans*-acid was obtained.

Treatment of the *cis*-diacid (0·2 g.) with diazomethane in ether gave the cis-*dimethyl ester*, plates (from ether–methanol), m. p. 160° (Found: C, 73·8; H, 5·9. $C_{19}H_{18}O_4$ requires C, 73·5; H, 5·8%). The *trans*-acid (0·5 g.) with diazomethane gave the trans-*dimethyl ester*, blades, m. p. 163—165° (from ether) (Found: C, 73·1; H, 5·8%). The m. p. of a mixture of the *cis*- and the *trans*-dimethyl ester was lower than that of either isomer.

When the *cis*- and *trans*-dicarboxylic acids (0·8 g.) were heated severally with acetic anhydride (2·0 ml.) for 6 min. and cooled, 0·54 g. (67%; m. p. 219°) and 0·26 g. (32%; m. p. 212°) respectively of the *cis*-anhydride crystallised.

cis-9,10-*Dihydroanthracene*-10-*carboxymonomorpholide*-9,10-*dicarboxylic Acid* (Ia; R = R′ = H, R″ = CO_2H, R‴ = $CO{\cdot}NC_4H_8O$).—Powdered *cis*-9,10-dihydroanthracene-9,10-dicarboxylic anhydride[6] (1·0 g.) was dissolved in cold 10% aqueous morpholine (50 ml.), and the solution immediately acidified with concentrated hydrochloric acid. This precipitated the acid morpholide (1·3 g., 96%), m. p. 261° alone or mixed with the authentic *cis*-acid morpholide[1] (Found: equiv., 338. Calc. for $C_{20}H_{19}NO_4$: equiv., 337).

cis-9,10-*Dihydro*-9-*methyl*-10-*morpholinocarbonylanthracene*-9-*carboxylic Acid* (Ia; R = Me, R′ = H, R″ = CO_2H, R‴ = $CO{\cdot}NC_4H_8O$).—Powdered 9,10-dihydro-9-methylanthracene-9,10-dicarboxylic anhydride (5·0 g.) was dissolved in 10% aqueous morpholine. Acidification as above precipitated the cis-9-*methyl*-9-*acid* 10-*morpholide* (6·35 g.), needles, m. p. 250—251° (from acetic acid) (Found: C, 71·3; H, 6·0; N, 3·9. $C_{21}H_{21}NO_4$ requires C, 71·8; H, 6·0; N, 4·0%). The *methyl ester morpholide* was prepared by use of ethereal diazomethane and crystallised from ether as cubes, m. p. 148—149° (Found: C, 72·0; H, 6·2; N, 3·8. $C_{22}H_{23}NO_4$ requires C, 72·3; H, 6·3; N, 3·8%).

cis-9,10-*Dihydro*-9-*hydroxymethyl*-9-*methy-l*10-*morpholinomethylanthracene Hydrobromide* (Ia; R = Me, R′ = H, R″ = $CH_2{\cdot}OH$, R‴ = $CH_2{\cdot}NC_4H_8O,HBr$).—The preceding ester morpholide (4·8 g.) was reduced as above. The aqueous extracts were combined, made alkaline with 50% potassium hydroxide solution, and extracted with ether and chloroform. Evaporation of the combined organic layers gave a viscous yellow oil (3·24 g.), a portion of which (0·5 g.) was dissolved in boiling methanolic hydrogen bromide, cooled, and treated with ether. A resulting precipitate (0·46 g.) crystallised from butan-1-ol–ether to give the required *morpholinomethyl hydrobromide* (0·43 g., 52%), as needles which decomposed on being heated (Found: C, 62·4; H, 6·7; N, 3·5%; equiv., 401. $C_{21}H_{26}BrNO_2$ requires C, 62·4; H, 6·5; N, 3·5%; equiv., 404).

cis-9,10-*Dihydro*-10-*methoxycarbonyl*-9-*methylanthracene*-9-*carboxylic Acid* (Ia; R = Me, R′ = H, R″ = CO_2H, R‴ = CO_2Me).—Powdered 9,10-dihydro-9-methylanthracene-9,10-dicarboxylic anhydride (0·3 g.) was dissolved in boiling dry methanol (3 ml.) containing concentrated hydrochloric acid (1 drop). Evaporation of the solvent left the 10-*methyl ester* (0·30 g.). Crystallisation from benzene–light petroleum (b. p. 80—100°) and then from benzene gave plates (0·20 g., 59%), m. p. 150—152° (Found: C, 73·0; H, 5·4. $C_{18}H_{16}O_4$ requires C, 73·0; H, 5·4%).

Methyl cis-9,10-*Dihydro*-10-*methyl*-10-*morpholinocarbonylanthracene*-9-*carboxylate* (Ia; R = Me, R′ = H, R″ = $CO{\cdot}NC_4H_8O$, R‴ = CO_2Me).—The preceding ester (3·36 g.) was rapidly heated to the b. p. with purified thionyl chloride (5 ml.), then immediately cooled and evaporated under reduced pressure. The residue was dissolved in dry ether (300 ml.) and treated with morpholine (3 ml.), which immediately gave a white solid. Crystallisation from light petroleum (b. p. 80—100°) gave the *ester morpholide* (3·2 g., 79%), as prisms, m. p. 120—121° (Found: C, 72·3; H, 6·4; N, 4·0. $C_{22}H_{23}NO_4$ requires C, 72·3; H, 6·3; N, 3·8%).

cis-9,10-*Dihydro*-10-*hydroxymethyl*-9-*methyl*-9-*morpholinomethylanthracene* (Ia; R = Me, R′ = H, R″ = $CH_2{\cdot}NC_4H_8O$, R‴ = $CH_2{\cdot}OH$).—The last-mentioned morpholide ester (3·0 g.) was reduced and worked up as usual, except that the combined aqueous extracts were made alkaline with 20% sodium hydroxide solution and extracted with ether. Evaporation of the ether gave a yellow solid (1·6 g.) which, crystallised successively from benzene–light petroleum (b. p. 40—60°), benzene–ether, and benzene, gave the *amino-alcohol* (0·8 g., 30%) as colourless rods, m. p. 128—128·5° (Found: C, 77·7; H, 7·8; N, 4·4. $C_{21}H_{25}NO$ requires C, 78·0; H, 7·8; N, 4·3%).

This amino-alcohol (0·2 g.) was shaken overnight in dry pyridine (5 ml.) containing acetic anhydride (0·1 ml.), thus affording its *acetate* (0·16 g., 71%) as lozenges, m. p. 92—93° [from benzene–light petroleum (b. p. 60—80°)] (Found: C, 75·6; H, 7·5; N, 3·8. $C_{23}H_{27}O_3N$ requires C, 75·6; H, 7·5; N, 3·8%).

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