38. *The Synthesis of Four Dimethylchrysenes.*

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Preparations of 1,2-, 3,4-, 3,5-, and 2,12-dimethylchrysene are described.

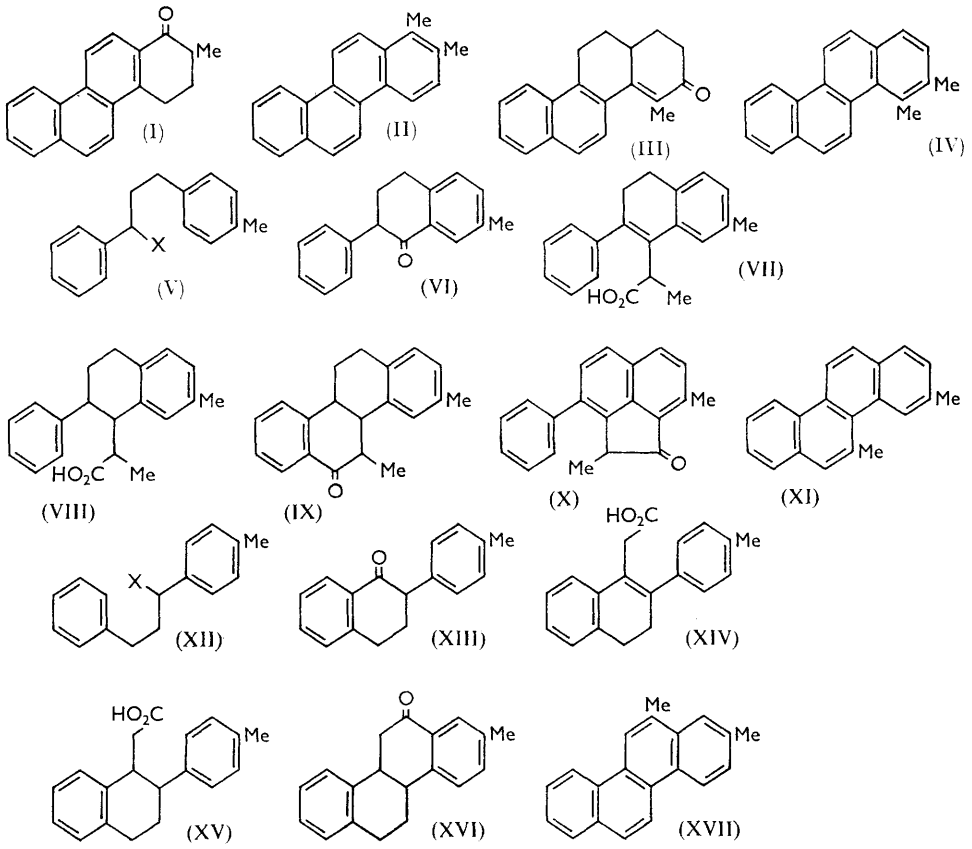
In connection with another investigation [1] we required to prepare the above named dimethylchrysenes. Tetracyclic precursors (I and III) being available,[2,3] they were treated with methylmagnesium bromide, and the products dehydrogenated with palladium–charcoal to yield 1,2- (II) and 3,4-dimethylchrysene (IV) respectively.

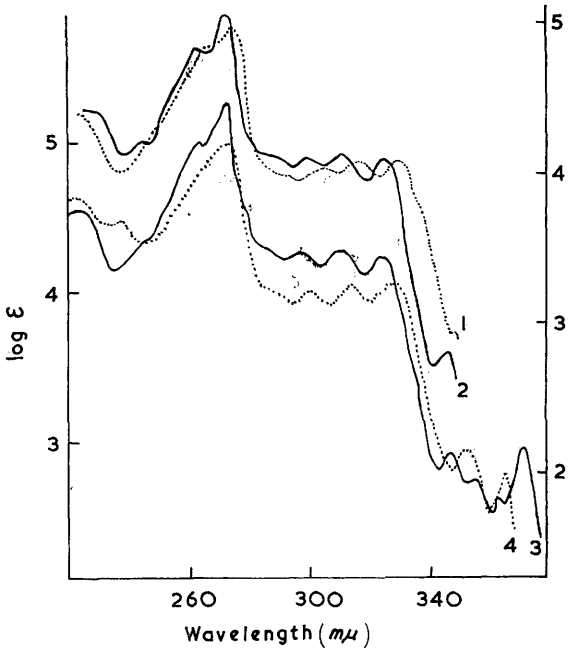
For the synthesis of 3,5- and 2,12-dimethylchrysene, the general route used by Newman [4] was adapted. For the preparation of the 3,5-dimethyl compound benzyl cyanide was alkylated with 4-methylphenethyl chloride (or bromide) to yield 1-phenyl-3-*p*-tolylpropyl cyanide (V; X = CN) which was hydrolysed to the corresponding acid (V; X = CO_2H) which had previously been prepared [5] by reduction of α-phenyl-β-*p*-toluoylpropionic acid. The acid (V; X = CO_2H) readily cyclised in the presence of anhydrous hydrogen fluoride to 7-methyl-2-phenyltetral-1-one (VI). This was converted into the unsaturated acid (VII) by a Reformatsky reaction with isobutyl α-bromopropionate followed by hydrolysis. The position of the double bond in the acid (VII) was assigned by analogy with previous work [4a] and from the similarity of the ultraviolet spectrum to that of *trans*-stilbene. Reduction of this acid (VII) to the saturated acid (VIII) could not be achieved by use of sodium amalgam or by catalytic hydrogenation (cf. ref. 4) but was readily effected with sodium in liquid ammonia (cf. ref. 6).

Cyclisation of the acid (VIII) with anhydrous hydrogen fluoride may give either the hydrochrysene derivative (IX) or the hydroacenaphthene derivative (X). The former would be expected to be the predominant, though not exclusive product, owing to the preferential formation of a six-membered ring.[7] The cyclisation product from the acid (VIII) was not homogeneous. It was reduced, dehydrated, and dehydrogenated and from the products was isolated 3,5-dimethylchrysene (XI) together with some impure material which had an infrared band at 14·25 μ characteristic [8] of a monosubstituted benzene and attributable to the presence of a phenyl-substituted acenaphthene derivative. The formation of an acenaphthene derivative has not previously been observed in cyclisations of this type (cf. ref. 4).

2,12-Dimethylchrysene was prepared by a similar reaction sequence, 4-methylbenzyl cyanide giving successively the cyanide (XII; X = CN), the acid (XII; X = CO_2H), and 2-*p*-tolyltetral-1-one (XIII). The ketone, on condensation with ethyl bromoacetate,

[1] Ansell and Brooks, *J.*, 1960, **1**, 201.
[2] Bachmann and Struve, *J. Org. Chem.*, 1940, **5**, 46.
[3] Wilds and Werth, *J. Org. Chem.*, 1952, **17**, 1149.
[4] Newman, *J. Amer. Chem. Soc.*, (*a*) 1938, **60**, 2947; (*b*) 1940, **62**, 870; (*c*) *ibid.*, p. 2295.
[5] Hidayetulla, Shah, and Wheeler, *J.*, 1941, 111.
[6] Robins and Walker, *J.*, 1957, 4984.
[7] Johnson, "Organic Reactions," Wiley, New York, 1944, Vol. IV, p. 114.
[8] Bellamy, "Infra-red Spectra of Complex Molecules," Methuen, London, 1954.





1, 3,4-*Dimethylchrysene.*
2, 1,2-*Dimethylchrysene.*
3, 2,12-*Dimethylchrysene.*
4, 3,5-*Dimethylchrysene.*
Curves 1 *and* 2—*right-hand scale.*

followed by hydrolysis, gave the unsaturated acid (XIV), which was reduced by sodium in liquid ammonia to the saturated acid (XV) and then cyclised to the hydrochrysene derivative (XVI). This cyclisation, as in the analogous cyclisation described above, may proceed in two ways. However, in this case the hydrochrysene (XVI) derivative was almost exclusively formed, although the presence of a second ketonic product, presumably a hydroacenaphthene derivative, was detected. This difference may be due to the fact that in the earlier case the chrysene derivative formed has a methyl group in the sterically hindered 5-position, thus increasing the proportion of the acenaphthene derivative (X) produced. The hydrochrysene derivative (XVI) was readily converted, by treatment with methylmagnesium iodide, followed by dehydrogenation with palladised charcoal, into 2,12-dimethylchrysene. A comparison of the ultraviolet absorption spectra (see Figure) of the above dimethylchrysenes shows that the principal maximum is not resolved when one of the methyl groups is present at either the 4- or the 5-position. A similar lack of resolution is found in the spectra of 4- and 5-monomethylchrysene.[9]

Experimental

1,2-*Dimethylchrysene*.—A solution of 1,2,3,4-tetrahydro-2-methyl-1-oxochrysene [2] (1·4 g.) in benzene (60 ml.) was added to a solution of methylmagnesium iodide [from magnesium (2 g.) and methyl iodide (6·4 ml.)] in ether (100 ml.). The mixture was boiled under reflux for 36 hr., then cooled and treated with water and sufficient 2N-hydrochloric acid to give two phases. The aqueous phase was extracted with benzene, and the combined extracts were washed with water. The residue (1·4 g.) obtained on evaporation of the benzene gave a positive reaction with Brady's reagent. It was boiled with a solution of Girard's reagent P (2·5 g.) in ethanol (40 ml.) and acetic acid (5 ml.) for 45 min. and then cooled, poured into water containing 2N-sodium hydroxide (37 ml.), and extracted with benzene. The non-carbonylic residue obtained on evaporation of the benzene extract was dehydrogenated at 300—310° with 5% palladised charcoal (1 g.). Extraction with benzene, crystallisation of the extracted material from benzene, and sublimation gave 1,2-*dimethylchrysene* (0·6 g.), m. p. 263—264° (Found: C, 93·7; H, 6·3. $C_{20}H_{16}$ requires C, 93·7; H, 6·3%). The 1,3,5-*trinitrobenzene complex* (orange-yellow needles from ethanol) had m. p. 196—198° (Found: C, 66·7; H, 4·1; N, 8·4. $C_{26}H_{19}N_3O_6$ requires C, 66·5; H, 4·1; N, 8·9%). The picrate appeared to be unstable and could not be obtained free from the hydrocarbon.

3,4-*Dimethylchrysene*.—A solution of 1,2,3,11,12,13-hexahydro-4-methyl-3-oxochrysene [3] (1 g.) in benzene (22 ml.) was added to one of methylmagnesium iodide [from magnesium (0·5 g.) and methyl iodide (1·6 ml.)] in ether (40 ml.), and the mixture boiled under reflux for 36 hr. The subsequent procedure was as for 1,2-dimethylchrysene. The dehydrogenation product was recrystallised from light petroleum (b. p. 60—80°) and ethanol and then sublimed to yield 3,4-*dimethylchrysene* (0·6 g.) (needles from light petroleum), m. p. 127·5—128·5° (Found: C, 93·5; H, 6·7%). The *picrate* (prepared in benzene; bright red needles from ethanol) had m. p. 133—134° (Found: C, 64·3; H, 3·9; N, 8·7. $C_{26}H_{19}N_3O_7$ requires C, 64·3; H, 4·0; N, 8·7%) and the 1,3,5-*trinitrobenzene complex* (prepared in benzene; orange-yellow needles from ethanol) had m. p. 166—167° (Found: C, 66·6; H, 4·1; N, 8·3%).

3-*Phenyl*-1-p-*tolylpropyl Cyanide*.—(*a*) 4-Methylbenzyl cyanide [10] (44 g., 0·33 mole) was added during 5 min. to a stirred cooled suspension of sodamide (13 g., 0·33 mole) in dry thiophen-free benzene (165 ml.) under nitrogen, and the mixture was then boiled under reflux for 1 hr. It was then cooled to 0° and phenethyl chloride [11] (22 g., 0·153 mole) added during 2 hr. (stirring). After being stirred for a further 3 hr. at room temperature it was heated under reflux for 30 min., then cooled and 2N-hydrochloric acid (300 ml.) added. The benzene layer was separated, washed with brine, and distilled to yield, after a small fore-run, 3-*phenyl*-1-p-*tolylpropyl cyanide* (14 g., 40%), b. p. 160—162°/0·09 mm., n_D^{20} 1·5592 (Found: N, 6·25. $C_{17}H_{17}N$ requires N, 6·0%).

(*b*) 4-Methylbenzyl cyanide (120 g.) was added to a stirred suspension of sodamide (from

[9] Jones, *J. Amer. Chem. Soc.*, 1941, **63**, 313; Brode and Patterson, *ibid.*, p. 3252.
[10] Atkinson and Thorpe, *J.*, 1907, **91**, 1697.
[11] Prepared from the corresponding alcohol as described by Ansell and Ducker (preceding paper), for 1-chloro-6-phenylhex-3-ene.

sodium, 22 g.) in liquid ammonia (600 ml.). Dry toluene (600 ml.) was added and the liquid ammonia distilled off. To the warm, stirred, red suspension was added, during 20 min., phenethyl bromide [12] (195 g.) with intermittent cooling, and the mixture was heated under reflux for 2 hr., then cooled and worked up as in method (*a*), to yield 3-phenyl-1-*p*-tolylpropyl cyanide (83 g., 38%), b. p. 150—160°/0·16—0·2 mm.

1-*Phenyl*-3-p-*tolylpropyl Cyanide*.—This *compound*, b. p. 156—162°/0·05 mm., n_D^{20} 1·5588 (analytical sample, b. p. 152°/0·04 mm., n_D^{20} 1·5598) (Found: N, 5·85. $C_{17}H_{17}N$ requires N, 6·0%), was prepared as for the isomeric cyanide in 33% yield by method (*a*) using benzyl cyanide (0·8 mole) and 4-methylphenethyl chloride [11] (0·7 mole) and method (*b*) (72% yield) using benzyl cyanide (1·3 moles) and 4-methylphenethyl chloride (0·55 mole).

γ-Phenyl-α-p-*tolylbutyric Acid*.—A mixture of 3-phenyl-1-*p*-tolylpropyl cyanide (10 g.), acetic acid (37·5 ml.), concentrated sulphuric acid (7 ml.) and water (5 ml.) was boiled under reflux for 66 hr. Water (10 ml.) was added, the mixture distilled under reduced pressure (water-pump) to remove most of the acetic acid and water, and the residue extracted with benzene and washed with water and saturated sodium carbonate solution. The alkaline washings were acidified with concentrated hydrochloric acid, and the precipitated acid was taken up in benzene. Distillation of the benzene extract gave *γ-phenyl*-α-p-*tolylbutyric acid* (8·0 g., 74%), b. p. 186°/0·1 mm., which solidified. A sample crystallised from light petroleum (b. p. 60—80°) had m. p. 74—76° (Found: C, 80·7; H, 7·3. $C_{17}H_{18}O_2$ requires C, 80·3; H, 7·1%).

α-*Phenyl*-γ-p-*tolylbutyric Acid*.—1-Phenyl-3-*p*-tolylpropyl cyanide (10 g.), treated as in the previous experiment, gave α-phenyl-γ-*p*-tolylbutyric acid (9·6 g., 88%), b. p. 160—165°/1—1·6 × 10^{-2} mm., which solidified (m. p. 76·5—78° after crystallisation from hexane) (lit.,[5] m. p. 80°).

2-p-*Tolyltetral*-1-*one*.—A solution of γ-phenyl-α-*p*-tolylbutyric acid (5 g.) in anhydrous hydrogen fluoride, contained in a Polythene beaker, was left overnight and then diluted with water and extracted with ether. The extract was washed with water and 10% aqueous sodium carbonate solution, dried ($MgSO_4$), and evaporated to yield 2-*p*-tolyltetral-1-one (4·4 g., 94%), m. p. 53—62°. One crystallisation (from methanol) gave the ketone, m. p. 72—74°. The analytical sample had m. p. 73—74° (Found: C, 86·4; H, 6·5. Calc. for $C_{17}H_{16}O$: C, 86·4; H, 6·8%). The 2,4-*dinitrophenylhydrazone* (red needles from ethanol–chloroform) had m. p. 226—227° (Found: N, 13·4. $C_{23}H_{20}N_4O_4$ requires N, 13·5%), and the *semicarbazone* (from ethanol–pyridine) had m. p. 192—194° (Found: N, 14·4. $C_{18}H_{19}N_3O_3$ requires N, 14·3%).

7-*Methyl*-2-*phenyltetral*-1-*one*.—α-Phenyl-γ-*p*-tolylbutyric acid (5 g.), treated as in the previous experiment, gave 7-methyl-2-phenyltetral-1-one (4·3 g., 92·5%), m. p. 62—66°. Crystallisation from methanol gave the pure ketone (prisms), m. p. 66—67° (lit.,[5] m. p. 67°). The 2,4-*dinitrophenylhydrazone* (red needles from chloroform) had m. p. 230—231° (Found: N, 13·2. $C_{23}H_{20}N_4O_4$ requires N, 13·5%), and the *semicarbazone* (from benzene–alcohol) had m. p. 234—236° decomp. (Found: N, 14·4. $C_{18}H_{19}NO_3$ requires N, 14·3%).

3,4-*Dihydro*-2-p-*tolyl*-1-*naphthylacetic Acid*.—A stirred mixture of 2-*p*-tolyltetral-1-one (37·5 g.), clean zinc foil (11 g.), ethyl bromoacetate (15 g.), a crystal of iodine, ether (300 ml.), and benzene (300 ml.) was boiled for 4 hr. During this time four additions of zinc foil (total, 44 g.), ethyl bromoacetate (total, 15 g.) and iodine were made at 30-min. intervals. After 2 hours' boiling an exothermic reaction ensued and spontaneous boiling occurred for *ca.* 20 min. At the end of the reaction time the mixture was cooled, and sufficient 2N-hydrochloric acid added to give two phases. The organic layer was separated and the aqueous layer extracted with benzene. Distillation of the combined extracts gave, after removal of the solvent, 42 g. of material, b. p. 180—190°/0·2 mm. The latter was hydrolysed by boiling with a solution of potassium hydroxide (45 g.) in water (250 ml.) and ethanol (250 ml.) for 18 hr. The bulk of the alcohol was removed by distillation under reduced pressure (water-pump) and the residue was extracted with benzene. The aqueous phase was acidified with concentrated hydrochloric acid, and the precipitated oil extracted with benzene. Concentration of the latter extract yielded 3,4-*dihydro*-2-p-*tolyl*-1-*naphthylacetic acid* (19 g.), m. p. 187—192°. Concentration of the mother-liquors gave a further 16·5 g. of the material which when recrystallised from acetic acid gave the acid (8·5 g.), m. p. 185—190°. An analytical sample [prisms from benzene–light petroleum (b. p. 60—80°)] had m. p. 185—191° (Found: C, 82·3; H, 6·4. $C_{19}H_{18}O_2$ requires C, 82·6; H, 6·5%).

α-(3,4-*Dihydro*-7-*methyl*-2-*phenyl*-1-*naphthyl*)*propionic Acid*.—This *acid* was prepared from

[12] Dolique, *Ann. Chim.* (*France*), 1931, **15**, 436.

7-methyl-2-phenyltetral-1-one and isobutyl α-bromopropionate on the same molar scale as in the previous experiment, *via* the intermediate ester (48 g.), b. p. 160—180°/0·2 mm. [yield of crude acid (21 g., 42·4%)], m. p. 150—174°. Crystallisation from ethanol gave the pure acid (13·5 g., 23%), m. p. 169—172° (Found: C, 82·5; H, 6·8. $C_{20}H_{20}O_2$ requires C, 82·2; H, 6·8%), $\lambda_{max.}$ 275 mμ (log ε 4·11) (in EtOH).

1,2,3,4-*Tetrahydro*-2-p-*tolyl*-1-*naphthylacetic Acid*.—Sodium (8 g.) was added in small portions during 5 min. to a stirred solution of 3,4-dihydro-2-*p*-tolyl-1-naphthylacetic acid (6·4 g.) in liquid ammonia (2 l.) and dry tetrahydrofuran (500 ml.). After 10 min. the colour of the solution was destroyed by the addition of propan-2-ol (100 ml.). The ammonia was left to evaporate overnight and the residue then treated with water (250 ml.), made acid with concentrated hydrochloric acid, and extracted with ether. The residue (6 g.) obtained on evaporation of the dried ($MgSO_4$) extract was crystallised from acetic acid (charcoal), to give 1,2,3,4-*tetrahydro*-2-p-*tolyl*-1-*naphthylacetic acid* (4·85 g.), m. p. 148—153°. An analytical sample (crystallised from alcohol) had m. p. 155—158·5 (Found: C, 81·4; H, 7·1. $C_{19}H_{20}O_2$ requires C, 81·4; H, 7·1%), $\lambda_{max.}$ 266 and 273 mμ, $\lambda_{min.}$ 235 and 270 mμ (log ε 2·85, 2·78, 2·37, and 2·68 respectively).

5,6,11,12,15,16-*Hexahydro*-2-*methyl*-12-*oxochrysene*.—The above acid (3·65 g.) was cyclised as for γ-phenyl-α-*p*-tolylbutyric acid. The non-acidic product (3·4 g.; m. p. 129—139°) was recrystallised twice from benzene–alcohol to yield 5,6,11,12,15,16-*hexahydro*-2-*methyl*-12-*oxochrysene* (1·4 g.) as plates, m. p. 140—142° (raised to 143—144° on further recrystallisation) (Found: C, 87·0; H, 6·9. $C_{19}H_{18}O$ requires C, 87·0; H, 6·9%). Its 2,4-*dinitrophenylhydrazone* (from chloroform–alcohol) partially melted at 160—180°, resolidified, and finally melted at 243—246° (decomp.) (Found: C, 67·4; H, 5·2; N, 12·7. $C_{25}H_{22}N_4O_4$ requires C, 67·9; H, 5·0; N, 12·7%). Chromatography, in ether–light petroleum (b. p. 60—80°) on alumina, of the residue obtained from evaporation of the ketone mother-liquors yielded a further 0·7 g. of the required ketone (m. p. 140—142°) together with a small amount of material, m. p. 78—127°, which afforded a red 2,4-dinitrophenylhydrazone, m. p. 145—150° (Found: C, 68·1; H, 5·1; N, 12·4. Calc. for $C_{25}H_{22}N_4O_4$: C, 67·9; H, 5·0; N, 12·7%).

2,12-*Dimethylchrysene*.—A solution of 5,6,11,12,15,16-hexahydro-2-methyl-12-oxochrysene (2·1 g.) in benzene (50 ml.) was added to a stirred solution of methylmagnesium iodide (from magnesium, 2 g.) in ether (40 ml.), and the mixture heated under reflux for 24 hr. The subsequent precedure was as for 1,2-dimethylchrysene (except that treatment with Girard's reagent was not necessary). The dehydrogenation product was sublimed (1·2 g.; m. p. 137—147°) and recrystallised from benzene–light petroleum (b. p. 60—80°), to yield 2,12-*dimethylchrysene*, needles, m. p. 150·5—151·5° (Found: C, 93·4; H, 6·4%). The *picrate* (red needles from benzene) had m. p. 187—188·5° (decomp.) (Found: C, 64·6; H, 3·9; N, 8·6%), and the 1,3,5-*trinitrobenzene complex* (yellow-orange needles from benzene) had m. p. 205—207·5° (Found: C, 66·3; H, 3·7; N, 8·7%).

3,5-*Dimethylchrysene*.—α-(3,4-Dihydro-7-methyl-2-phenyl-1-naphthyl)propionic acid (6·5 g.) was reduced as was 3,4-dihydro-2-*p*-tolyl-1-naphthylacetic acid. The products from two such reactions were combined and recrystallised from light petroleum (b. p. 60—80°) to yield α-(1,2,3,4-tetrahydro-7-methyl-2-phenyl-1-naphthyl)propionic acid (2·7 g.), m. p. 113—123°, $\lambda_{max.}$ 270, 278 (log ε 2·81, 2·81). Further recrystallisation did not raise the m. p. All of this acid was cyclised as for γ-phenyl-α-*p*-tolylbutyric acid by use of anhydrous hydrogen fluoride (35 ml.). The non-acidic product (2·2 g.), m. p. 65—95°, was fractionally crystallised from ethanol to yield material (1·3 g.), m. p. 95—100°, and material (0·3 g.), m. p. 78—83°. The former fraction (1·2 g.) was dissolved in dry ether (50 ml.), boiled with lithium aluminium hydride (2 g.) in ether (100 ml.) for 2 hr., and then cooled. Excess of hydride was decomposed by water, and the ether layer was decanted. Evaporation of the dried ($MgSO_4$) extract gave a partially solid, non-ketonic product which was heated with powdered fused potassium hydrogen sulphate at 180—200° for 45 min. in an atmosphere of nitrogen. The product was treated with water and extracted with benzene. The residue obtained on removal of the solvent was heated with 5% palladised charcoal (1 g.) at 300—320° for 4 hr. The product was extracted with benzene, the catalyst removed, and the solvent evaporated. The residual partly solid product was distilled (150—180°/0·1 mm.). The partly solid distillate was washed with cold ether (extract A) and then crystallised from benzene–ethanol and from light petroleum (b. p. 60—80°), to yield 3,5-*dimethylchrysene*, m. p. 126—128·5° (Found: C, 93·7; H, 6·3%). The *picrate* (red needles from benzene) had m. p. 150—154° (Found: N, 8·7%).

The liquid dehydrogenation product from extract A was chromatographed in light petroleum (b. p. $<40°$) on alumina but no further solid was obtained. The infrared spectrum of the liquid product showed absorption at 12·03 and 14·25 μ, indicating a free phenyl group.

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