133. *Experiments on the Synthesis of Substances related to the Sterols. Part XLII.*

By R. H. Martin and Sir Robert Robinson.

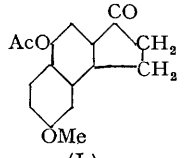
This communication records extensions of the work of Robinson (J., 1938, 1390) and Bateman and Robinson (J., 1941, 398) in the 3′-substituted *cyclo*pentenonaphthalene series. An improved preparation of 3′-keto-4-hydroxy-1 : 2-*cyclo*pentenonaphthalene is described, and its *methyl* ether (II, R = Me) submitted to the Reformatzky reaction with ethyl bromoacetate, and oxidised by means of selenium dioxide to an *α-diketone*. The latter reaction has also been applied to 3′-keto-4 : 6-dimethoxy-1 : 2-*cyclo*pentenophenanthrene, and the *diketone* oxidised to a *dicarboxylic acid*. 3′-*Keto*-4-*acetoxy*-7-*methoxy*-1 : 2-cyclo*pentenonaphthalene* (I) has been

obtained by the usual series of operations from *m*-methoxyacetophenone, but an attempt to prepare a 3′-keto-6-methoxy-5-methyl*cyclo*pentenonaphthalene derivative failed because one of the earlier processes in the synthesis took an abnormal course. Substances of the type mentioned would be valuable intermediates for the synthesis of analogues of progesterone and corticosterone.

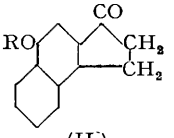
The hydrogenation of 4 : 6-dimethoxy-1 : 2-*cyclo*pentadienonaphthalene-3′-acetic acid has been re-investigated. It is shown that reduction occurs in the terminal aromatic nucleus.

BATEMAN and ROBINSON (*loc. cit.*) found that 3-*p*-methoxyphenyl-Δ^2-*cyclo*penten-1-one-2-acetic acid was readily cyclised by means of acetic anhydride at 170—190°. As the ring-closure occurred in the *m*-position to a methoxyl group, it occurred to us that migration was a possibility (cf. Hayashi, J., 1930, 1513) and in this case the product would have been 3′-*keto*-4-*acetoxy*-7-*methoxy*-1 : 2-cyclo*pentenonaphthalene* (I). The synthesis of this substance has proved that the punctilio was unnecessary.

The action of acetic anhydride on 3-phenyl*cyclo*pentenoneacetic acid affords 3′-*keto*-4-*acetoxy*-1 : 2-cyclo*pentenonaphthalene* (II, R = Ac) in good yield and the corresponding *methyl* ether (II, R = Me) yields (III) by the Reformatzky reaction, followed by hydrolysis and reduction. This *acid* was required as a reference



(I.)



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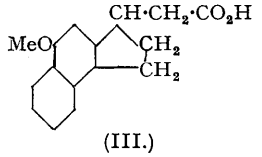
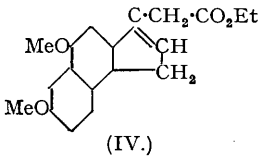


(III.)

compound in connexion with experiments on the hydrogenation of 4 : 6-dimethoxy-1 : 2-*cyclo*pentadienonaphthalene-3′-acetic acid (IV), already studied by Bateman and Robinson (*loc. cit.*). One of the main products isolated in the earlier work was an ester, m. p. 45—50°, which gave an acid, $C_{17}H_{22}O_4$, m. p. 117—118°. We have now found that this acid is a mixture (probably of stereoisomerides) and the main constituent ($C_{17}H_{22}O_4$) has m. p. 131—132·5° and the structure (V). On treatment with hydriodic acid and remethylation it yields



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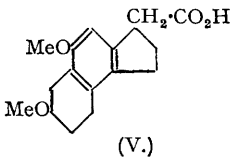

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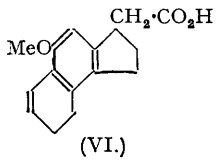

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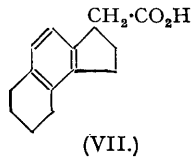


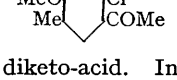
(VII.)

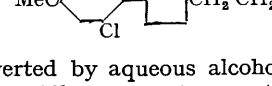
an *acid*, regarded as (VI), and this on dehydrogenation (by way of its ester) is converted into (III). The uncrystallisable acids obtained by hydrolysis of the hydrogenation product gave no pure compounds by direct separation. After dehydrogenation of the methyl esters and hydrolysis, an *acid*, believed to be (VII), was isolated. An alternative interpretation is mentioned below.

As an intermediate for 3′-keto-6-methoxy-5-methyl*cyclo*pentenonaphthalene we wished to have a ready source of 4-chloro-*o*-tolyl methyl ether and were led to investigate the nitration of *o*-tolyl carbonate in the hope that nitration would occur in the *p*-position to the methyl group. Copisarow (J., 1929, 588) had already shown that the nitration of *p*-tolyl carbonate proceeds in the *o*-position to the methyl group. However, in the case of *o*-tolyl carbonate, nitration occurs almost exclusively para to the oxygen, an interesting contrast.

We are grateful to Messrs. I.C.I. (Dyestuffs) Ltd. for a supply of 4-chloro-2-nitrotoluene, from which 4-*chloro*-o-*tolyl methyl ether* was prepared by standard methods. The Friedel–Crafts reaction then afforded 2-*chloro*-4-*methoxy*-5-*methylacetophenone* (VIII). The *furfurylidene* derivative of this ketone could not be hydrolysed

(VIII.)





(IX.)

in the usual way to a diketo-acid. Instead it was converted by aqueous alcoholic hydrogen chloride into 2-(4′-*chloro*-6′-*methoxy*-m-*tolyl*)*furan*-5-β-*propionic acid* (IX). All attempts to open the furan ring failed and the projected synthesis could not be realised.

EXPERIMENTAL.

3′-*Keto*-4-*acetoxy*-1 : 2-cyclo*pentenonaphthalene* (II, R = Ac).—A mixture of 3-phenyl-Δ^2-*cyclo*penten-1-one-2-acetic acid (14·1 g.) (Robinson, *loc. cit.*) and acetic anhydride (60 c.c.) was heated in a stout sealed flask at 190° for 1 hour. On cooling, finally rapidly in ice-water, 11·65 g. of crystals, m. p. 156—158°, separated and 1·15 g. more were obtained by concentration of the mother-liquor. The *derivative* was crystallised from methanol, sublimed at 155°/0·3 mm., and recrystallised from methanol, forming thick white needles, m. p. 159—160° (Found: C, 74·9; H, 4·9. $C_{15}H_{12}O_3$ requires C, 75·0; H, 5·1%). On hydrolysis with aqueous alcoholic sodium hydroxide and acidification the corresponding phenol was obtained and this exhibited all the properties of the substance previously obtained by the much inferior process of cyclisation by means of sulphuric acid (*loc. cit.*). The corresponding *methyl* ether (II, R = Me) was prepared from both specimens and a mixture showed no depression of m. p. The acetate was treated with alcoholic potassium hydroxide and methyl sulphate until the yellow colour of the alkaline solution was quite faint. The substance (yield, almost quantitative) was crystallised from ethyl acetate, sublimed at 135°/0·3 mm., and crystallised from alcohol, being so obtained in small, white needles, m. p. 127·5—128·5° (Found: C, 79·4; H, 5·7. $C_{14}H_{12}O_2$ requires C, 79·2; H, 5·7%).

The solution in sulphuric acid had a bright yellow colour. The dark red 2 : 4-*dinitrophenylhydrazone* of the methyl ether separated from xylene in microscopic crystals, m. p. 301° (Found : C, 61·3; H, 4·3. $C_{20}H_{16}O_5N_4$ requires C, 61·2; H, 4·1%).

4-*Methoxy*-1 : 2-cyclo*pentadienonaphthalene*-3'-*acetic Acid*.—A mixture of ketomethoxy*cyclo*pentenonaphthalene (3 g.), ethyl bromoacetate (4·8 g.), zinc ribbon (2·6 g.), and benzene (45 c.c.) was refluxed for 2 hours and then decomposed with ice and hydrochloric acid. The benzene layer was freed from acids, dried, and evaporated, and the residual yellowish-brown cake crystallised from methanol (yield, 2·9 g.). The yellow colour can be removed by means of alumina or charcoal. For analysis the *substance* was sublimed at 120°/0·05 mm. and crystallised twice from methanol; it formed white needles, m. p. 123—123·5° (Found : C, 76·9; H, 6·8. $C_{18}H_{18}O_3$ requires C, 76·6; H, 6·5%). Hydrolysis with methanolic sodium methoxide, followed by gradual addition of water, and later, hydrochloric acid, gave the corresponding *acid*, which was twice crystallised from a little acetone (refrigerator), sublimed at 190°/0·01 mm., and recrystallised from acetone It formed minute, colourless needles, m. p. 226—228° (decomp.) (Found : C, 75·5; H, 5·8. $C_{16}H_{14}O_3$ requires C, 75·6; H, 5·6%).

4-*Methoxy*-1 : 2-cyclo*pentenonaphthalene*-3'-*acetic Acid* (III).—The above ester (1·9 g.) in methanol (30 c.c.) was hydrogenated at 18°/2 atms. for 8 hours in the presence of palladised strontium carbonate (1·2 g. of 2%). The product distilled (bath at 190—200°/0·15 mm.) as a very pale yellow oil (1·8 g.) which did not crystallise on keeping at 0°. It was hydrolysed by refluxing with methanolic potassium hydroxide and a few drops of water. The *acid* was isolated in the usual way, twice crystallised from aqueous acetic acid, sublimed at 150°/0·5 mm., and recrystallised from aqueous methanol. It formed colourless prismatic needles, m. p. 132—137°, containing solvent; it was therefore resublimed, m. p. 136—137·5° after slight sintering (Found : C, 75·1; H, 6·2. $C_{16}H_{16}O_3$ requires C, 75·0; H, 6·3%).

2' : 3'-*Diketo*-4-*methoxy*-1 : 2-cyclo*pentenonaphthalene*.—A mixture of ketomethoxy*cyclo*pentenonaphthalene (1 g.), selenium dioxide (0·5 g.), and acetic acid (15 c.c.) was boiled for 3 minutes, mixed with a little water, and cooled. The precipitated *product*, thrice crystallised from acetone, formed yellow, microscopic prisms, m. p. 178—180° (Found : C, 73·7; H, 4·3. $C_{14}H_{10}O_3$ requires C, 74·3; H, 4·5%).

Furfurylidene-3-*methoxyacetophenone*.—Following the elegant method of Claisen for the preparation of ethyl benzoylacetate, *m*-methoxybenzoyl chloride (54 g., from thionyl chloride and the acid) and ethyl acetoacetate (41·2 g.) were used; the successive hydrolyses were effected by means of 10% aqueous ammonia and boiling 10% aqueous sodium hydroxide. The ketone, b. p. 138—139°/24 mm. (yield, 32·6 g. or 68·5%), gave a semicarbazone, m. p. 195—197° after crystallisation from dioxan, these data being in agreement with the records (cf. Wahl and Silberzweig, *Bull. Soc. chim.*, 1912, **11**, 61). The condensation with furfuraldehyde (1 mol.) was carried out in cold methanolic solution containing 1% of sodium methoxide; the product, collected by means of ether, distilled as a light yellow oil, b. p. 185°/0·6 mm. (yield, 92%). A redistilled specimen, b. p. 175°/0·45 mm., solidified in the ice-chest. The *substance* crystallised from light petroleum (b. p. 60—80°) (charcoal) in small, pale yellow needles, m. p. 38·5—39·5°, which became brownish-red on keeping (Found : C, 74·2; H, 5·7. $C_{14}H_{12}O_3$ requires C, 73·7; H, 5·3%). Analysis of several specimens failed to give sharper figures. The solution in sulphuric acid had a deep red colour and the dark red 2 : 4-*dinitrophenylhydrazone*, crystallised from acetic acid, had m. p. 190—191° (Found : C, 58·8; H, 4·0. $C_{29}H_{16}O_6N_4$ requires C, 58·8; H, 4·0%). Following the usual procedure (Kehrer and Igler, *Ber.*, 1899, **32**, 1178; Robinson, *loc. cit.*) the furfurylidenemethoxyacetophenone gave 4 : 7-*diketo*-m-*methoxyphenylheptoic acid*, which, crystallised from water containing a little acetic acid (charcoal), formed white needles, m. p. 87—88° (Found : C, 63·9; H, 5·9. $C_{14}H_{16}O_5$ requires C, 63·6; H, 6·1%).

3'-*Keto*-4-*acetoxy*-7-*methoxy*-1 : 2-cyclo*pentenonaphthalene* (I).—The above diketo-acid was cyclised as usual by boiling 2% aqueous potassium hydroxide; the product was a yellow oil (21·5 g. from 60 g. of furfurylidenemethoxyacetophenone). The substance crystallised with some difficulty from ethyl acetate–light petroleum in the refrigerator and was recrystallised successively from benzene, ethyl acetate, and benzene. 3-m-*Methoxyphenyl*-Δ^2-cyclo*penten*-1-*one*-2-*acetic acid* formed thick, colourless prisms, m. p. 100—101° (Found : C, 68·1; H, 5·8. $C_{14}H_{14}O_4$ requires C, 68·3; H, 5·8%). The crude acid (15 g.) was boiled with acetic anhydride (25 c.c.) for 1½ hours, and, on rapid cooling, 10·6 g. of a nearly white powder separated. The *substance* was crystallised from alcohol, aqueous acetic acid, dioxan, and finally from alcohol and obtained in white needles, m. p. 177·5—178° (Found : C, 71·3; H, 4·9. $C_{16}H_{14}O_4$ requires C, 71·1; H, 5·2%). The solution in sulphuric acid was yellow and by hydrolysis a phenol was obtained which dissolved in alkali to a yellow solution and coupled with *p*-nitrobenzenediazonium salts to a red azo-compound. The original mother-liquor contained a more readily soluble isomeride, evidently 3'-*keto*-4-*acetoxy*-5-*methoxy*-1 : 2-cyclo*pentenonaphthalene*, which was obtained in a pure condition only after a laborious series of fractional crystallisations from alcohol, dioxan, methanol and ether, as well as passage of a solution in benzene through an alumina column. In this way 1·3 g. of the 7-methoxy-compound and 0·3 g. (m. p. 192—196°) of the 5-methoxy-compound were isolated. The latter was sublimed at 170—180°/0·1 mm., crystallised twice from methanol, and sublimed again, forming white needles, m. p. 196·5—198° (Found : C, 70·7; H, 5·2. $C_{16}H_{14}O_4$ requires C, 71·1; H, 5·2%). The following mixtures showed large depressions of m. p. : 6-MeO, 7-MeO; 6-MeO, 5-MeO; 7-MeO, 5-MeO.

Hydrogenation of 4 : 6-*Dimethoxy*-1 : 2-cyclo*pentadienonaphthalene*-3'-*acetic Acid* (cf. Bateman and Robinson, *loc. cit.*).—There is not much real evidence in regard to the position of the double bond in this ester. Other things being equal, an indene structure would be anticipated, but it was described as a yellow substance and this favoured an exocyclic constitution. We have now found that the colour is due to an impurity which cannot be removed by crystallisation. Sublimation in a high vacuum afforded a colourless product which crystallised in white needles of unaltered m. p. The ester (10 g.) was reduced under the same conditions as heretofore, except that the solvent (alcohol) was reduced to 60 c.c. and the time of reaction to 10 hours. After hydrolysis with alcoholic potassium hydroxide, and crystallisation of the resulting acid from benzene–light petroleum (b. p. 60—80°), 3·6 g., m. p. 117—118°, were isolated and the material was identical with that previously obtained, for which analysis indicated the formula $C_{17}H_{22}O_4$. Under milder conditions (145—150°/125 atms.) the acid, produced in equal yield, had m. p. 124—125°, raised to 131—132·5° by crystallisation from benzene–light petroleum (Found : C, 70·1; H, 7·6. $C_{17}H_{22}O_4$ requires C, 70·3; H, 7·6%). It was then found that the m. p. of the acid, m. p. 117—118°, could be raised to 129° by fractional crystallisation. In one case a mixture of needles and plates separated, but these, when hand-picked, showed the same m. p. and mixed m. p. The m. p. of mixed fractions was always between the values for the constituents. Taking into account the analytical data and the chemical behaviour of the material, m. p. 117—118°, there can be no doubt that it is a mixture of closely related stereoisomerides. It is shown below that the constitution is that of 4 : 6-*dimethoxy*-5 : 6 : 7 : 8-*tetrahydro*-1 : 2-cyclo*pentenonaphthalene*-3'-*acetic acid* (V), which should occur in two inactive stereoisomeric forms. The rings should be co-planar and very little is known of the physical behaviour of mixtures of stereoisomerides in which the groups responsible for *cis-trans*-configurations are so far removed from one another in the molecule. A mixture of the acids (2 g., m. p. 117—118°), hydriodic acid (7 c.c., *d* 1·7), and acetic acid (7 c.c.) was refluxed for ½ hour. The product was isolated by means of ether and freed from iodine; it formed a greenish solid and was at once methylated by means of methyl sulphate (10 c.c.) and potassium hydroxide in aqueous methanol. The isolated, acidic product was sublimed at 150°/0·0025 mm. (0·6 g.). It separated from aqueous acetic acid in white, microscopic crystals and was then resublimed, m. p. 154·5—156·5° (Found : C, 74·0; H, 7·4. $C_{16}H_{18}O_3$ requires C, 74·4; H, 7·0%). The acid absorbs bromine in chloroform solution without

liberation of hydrogen bromide and its ester may be dehydrogenated with unusual ease (see below). It is therefore certainly a dihydronaphthalene derivative and almost certainly 4-*methoxy*-7 : 8-*dihydro*-1 : 2-cyclo*pentenonaphthalene*-3′-*acetic acid* (VI).

In order to avoid loss of carbon dioxide, the sublimed acid (0·6 g.) was esterified with ethereal diazomethane from 2 c.c. of nitrosomethylurethane; the derivative was an oil which later crystallised, but was not further investigated. It was heated with palladised charcoal (0·1 g.) under nitrogen and hydrogen was evolved at 180°. To ensure completion of the reaction the mixture was heated at 300° for 2½ hours. After hydrolysis of the product the acid was sublimed at 140°/0·0025 mm., crystallised from aqueous methanol, and resublimed, m. p. 135° and m. p. 136—136·5° when mixed with an equal quantity of pure 4-methoxy-1 : 2-*cyclo*pentenonaphthalene-3′-acetic acid, m. p. 136—137°. The oxygen eliminated in the treatment with hydriodic acid is therefore that of the 6-methoxyl group and, further, this group is situated in the hydrogenated nucleus.

The uncrystallisable acids in the mother-liquors from the acids, m. p. 117—118° and m. p. 124—125°, were twice distilled, b. p. 160—167°/0·03 mm. The analyses were not satisfactory (*e.g.*, Found : C, 76·3; H, 8·9%) and indicated complex mixtures of substances that have suffered loss of one and two oxygen atoms. The mixture was heated with palladised charcoal under nitrogen; carbon dioxide was evolved below 150°. The temperature was maintained at 280° for 8 hours. On working up, a neutral product, b. p. 180—200°/17 mm., was obtained as a clear, mobile oil, $n_D^{20°}$ 1·6005 (Found : C, 87·6; H, 7·9%). We interpret this as a mixture of $C_{14}H_{14}$ and $C_{15}H_{16}O$. In order to avoid decarboxylation the distilled oily acids were esterified with diazomethane, and the ester heated with palladised charcoal under nitrogen. Evolution of gas started at 140—150° and the temperature was raised to 220° during 2 hours and maintained for 1 hour more. The resulting ester was hydrolysed, and the *acid* crystallised from benzene–light petroleum (b. p. 60—80°) and then many times from aqueous methanol and aqueous acetic acid. It was obtained in white plates, m. p. 109·5—111·5° (Found : C, 78·2; H, 7·4. $C_{15}H_{18}O_2$ requires C, 78·2; H, 7·9%). There was a large depression of m. p. on admixture with the naphthalenoid acid, m. p. 136—137°, and a dihydronaphthalene would be most unlikely to resist the dehydrogenation process. Indeed it is curious that the tetralin derivative (VII) can do so and an alternative possibility is that the *cyclo*pentane ring is opened by the reduction at 3′ : 2′ or 3′ : 4′. For example, in the former case the acid would be δ-1-naphthylvaleric acid ($C_{15}H_{18}O_2$ requires C, 78·9; H, 7·0%). The oily acids in the mother-liquor had b. p. 205°/0·03 mm. (Found : C, 76·4; H, 8·4%). We can reach no conclusion from these figures. Some crystals which separated after several months were not further investigated.

o-*Tolyl Carbonate*.—Einhorn and Hollandt (*Annalen*, 1898, **301**, 95) prepared the substance (m. p. 60°, analysis) by the action of carbonyl chloride on a pyridine solution of *o*-cresol. Subsequently the literature of the subject has been much confused. Barrel and Morel (*Bull. Soc. chim.*, 1899, **21**, 727) claim that they obtained the carbonate by distillation of *o*-tolyl chloroformate (b. p. 114°/25 mm.) at the ordinary pressure and give m. p. 80°, but no analysis. Copisarow (J., 1929, 588) passed carbonyl chloride into a solution of *o*-cresol in aqueous sodium hydroxide at 70—75° and reported an 85% yield of *o*-tolyl carbonate, a colourless oil (no analysis).

We have repeated this preparation and obtained the oil, which was readily separated into two fractions. From 108 g. of *o*-cresol we obtained 55 g., b. p. 84°/15 mm., and 50 g., b. p. 144—145°/0·5 mm. The latter fraction solidified and, after several crystallisations from alcohol and methanol, had m. p. 57—57·5° (Found : C, 74·3; H, 6·1. Calc. for $C_{15}H_{14}O_3$: C, 74·4; H, 5·8%). The first fraction contained chlorine and should be *o*-tolyl chloroformate. Its behaviour was quite different from that recorded by Barrel and Morel (*loc. cit.*) because it was recovered unchanged after refluxing for 2 hours at the ordinary pressure. On the other hand, it was converted into *o*-tolyl carbonate in almost quantitative yield on treatment with pyridine in benzene solution.

Nitration. Copisarow's method (*loc. cit.*) for *p*-tolyl carbonate was followed in essentials. The nitration of 10 g. was effected by nitric acid (4·8 c.c., *d* 1·43) and sulphuric acid (33 c.c. in all) first at −15°, then at −10° and finally at 0°. The product was hydrolysed by means of boiling aqueous potassium carbonate (22 g. in 150 c.c.), acidified, and steam-distilled. Slender yellow needles (0·3 g.) of 3-nitro-*o*-cresol, m. p. 69° (Gibson, J., 1925, **127**, 42, gives m. p. 70°), were collected from the distillate after the first few minutes and no more was obtained later. The main product was isolated by means of ether and distilled, b. p. 132°/0·2 mm. (9·2 g.). After crystallisation it formed faintly yellow needles, m. p. 82—84° and was identified as 5-nitro-*o*-cresol (Spiegel, Munblit, and Kaufmann, *Ber.*, 1906, **39**, 3240, give m. p. 82—85°). 4-Nitro-*o*-cresol was obtained in another experiment (final temperature 10°) and separated (0·3 g.) on acidification of the solution of the hydrolysed products. It formed cream needles, m. p. 116—117° (Ullmann and Fitzenkam, *Ber.*, 1905, **38**, 3787, give m. p. 118°). Thus there is evidence of the formation of small relative amounts of the carbonate of 3- and 4-nitro-*o*-cresols, but 5-nitro-*o*-cresol, a derivative of *p*-nitrophenol, constitutes more than 90% of the product.

Furfurylidene-6-*chloro*-4-*methoxy*-3-*methylacetophenone*.—Zinc dust (120 g.) was added with shaking to a solution of 4-chloro-2-nitrotoluene (50 g.) in acetic acid (500 c.c.), and the mixture refluxed for 1 hour. The resulting base (yield, 70%) was isolated in the known manner; b. p. 111°/9 mm., m. p. 20—21°, in agreement with Goldschmidt and Hönig (*Ber.*, 1886, **19**, 2440). 4-Chloro-*o*-toluidine sulphate (164·5 g.) was made into a paste with water (600 c.c.) and sulphuric acid (100 c.c.) and diazotised at 8—10° by addition of sodium nitrite (60 g.) in water (150 c.c.). One-third of the solution was slowly added to water (500 c.c.) and sulphuric acid (80 c.c.) while a rapid current of steam was passed. The other two-thirds were treated in the same way. From the distillates, 109 g. of 4-chloro-*o*-cresol were collected, m. p. 72° after crystallisation from light petroleum (b. p. 40—60°) (Zincke and Preiss, *Annalen*, 1918, **417**, 207, give m. p. 73—74°). Methylation by means of methyl sulphate and potassium hydroxide gave 90·5 g. of 4-chloro-*o*-tolyl methyl ether, b. p. 91—92°/13 mm. A solution of this (88 g.) and acetyl chloride (50 c.c.) in carbon disulphide (100 c.c.) was gradually added to a well-stirred suspension of aluminium chloride (85 g.) in carbon disulphide (250 c.c.) with cooling in ice-water. After 2 hours, the mixture was kept at room temperature for 2 hours and then refluxed for 3 hours (50 c.c. more carbon disulphide). The product (108 g. or 97%) had b. p. 158—160°/18—19 mm. It crystallised from light petroleum (b. p. 40—60°) in white needles, m. p. 45·5—46° (Found : C, 60·0; H, 5·5. $C_{10}H_{11}O_2Cl$ requires C, 60·4; H, 5·6%). A mixture of 6-*chloro*-4-*methoxy*-3-*methylacetophenone* (VIII) (100·5 g.), furfuraldehyde (43·5 c.c.), and methanol (100 c.c.) was stirred while methanolic sodium methoxide (0·85 g. of sodium in 85 c.c.) was gradually introduced. The *product* crystallised after about an hour and was collected after 12 hours (118 g., m. p. 77—78°). The derivative crystallised from light petroleum (b. p. 60—80°) in light yellow plates, m. p. 78—79° (Found : C, 65·1; H, 4·8. $C_{15}H_{13}O_3Cl$ requires C, 65·1; H, 4·8%).

2-(4′-*Chloro*-6′-*methoxy*-m-*tolyl*)*furan*-5-β-*propionic Acid* (IX).—A mixture of the above furfurylidene derivative (135 g.), alcohol (1·5 l.), and concentrated hydrochloric acid (400 c.c.) was refluxed for 18 hours. The alcohol was distilled under diminished pressure and the residual gum was separated and extracted repeatedly with boiling mixtures of acetic acid (200 c.c.), concentrated hydrochloric acid (100 c.c.), and water (150 c.c., finally reduced to 100 c.c.). A brownish crystalline powder separated on cooling (total, 41·6 g.). In all other cases so far examined, this procedure affords aryldiketoheptoic acids but in this example the related *furan* is the sole product. The substance was thrice crystallised from aqueous dioxan (charcoal), sublimed at 160°/0·005 mm., and crystallised from dioxan and from ethyl acetate. It formed faintly yellow needles, m. p. 175—177° after slight sintering (Found : C, 61·4; H, 5·5. $C_{15}H_{15}O_4Cl$ requires C, 61·1; H, 5·2%). The sodium salt is very sparingly soluble. The *methyl* ester was prepared by treatment with boiling saturated

methanolic hydrogen chloride (in the hope that the furan ring might be opened) and crystallised twice from light petroleum and then from aqueous acetic acid (charcoal). It formed colourless needles, m. p. 77—78° (Found : C, 62·8, 62·8; H, 5·6, 5·6; Cl, 11·5. $C_{16}H_{17}O_4Cl$ requires C, 62·2; H, 5·6; Cl, 11·4%). The derivative was also obtained by esterification of the acid with diazomethane.

2′ : 3′-*Diketo*-4 : 6-*dimethoxy*-1 : 2-cyclo*pentenonaphthalene*.—When a mixture of 3′-keto-4 : 6-dimethoxy-1 : 2-*cyclo*pentenonaphthalene (Bateman and Robinson, *loc. cit.*) (5 g.), acetic acid (50 c.c.), and selenium dioxide (5 g.) was raised to the b. p., a vigorous reaction set in; it proceeded without further heating. When it had subsided, the solution was boiled for 1 minute, acetic acid (150 c.c.) added, and the mixture boiled for 2 minutes and filtered. Water (50 c.c.) was added, and the orange solid collected after cooling (4·7 g.). The *diketone* crystallised from acetic acid in deep brownish-orange needles, m. p. 243—245° (decomp.) (Found : C, 70·0; H, 4·9. $C_{15}H_{12}O_4$ requires C, 70·3; H, 4·7%). The solution in sulphuric acid had an intense brownish-crimson colour. The deep yellow *quinoxaline* derivative obtained with *o*-phenylenediamine crystallised from acetic acid–alcohol in needles, m. p. 247° (Found : C, 76·5; H, 5·0; N, 8·4. $C_{21}H_{16}O_2N_2$ requires C, 76·8; H, 4·9; N, 8·5%). It formed a red, sparingly soluble hydrochloride and gave a blue solution in sulphuric acid. The yellow solution in toluene fluoresced blue.

2-*Carboxy*-4 : 6-*dimethoxynaphthalene*-1-*acetic Acid*.—A mixture of the above diketone (3·0 g.), water (25 c.c.), 10% sodium hydroxide solution (20 c.c.), and hydrogen peroxide (15 c.c. of 20 vol.) was gently heated with stirring and then raised to the b. p. in 5 minutes. After addition of 10% sodium hydroxide solution (10 c.c.) and hydrogen peroxide (10 c.c. of 20 vol.) the mixture was allowed to cool and then boiled for 5 minutes. On acidification of the filtered solution, 2·9 g. of the *acid* separated. The orange residue was probably a self-condensation product of the diketone; it dissolved in sulphuric acid to an opaque blue-black solution. The acid was readily soluble in acetone and crystallised from acetic acid in colourless aggregates of microscopic needles and flat, elongated, prismatic needles, m. p. 255—257° (decomp.) (Found : C, 58·0; H, 5·2. Found in material dried at 110° in a high vacuum : C, 61·9; H, 5·0. $C_{15}H_{16}O_7$ requires C, 58·4; H, 5·2%. $C_{15}H_{14}O_6$ requires C, 62·1; H, 4·8%).

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