195. *Synthetical Experiments in the Chromone Group. Part XVI. Chalkones and Flavanones and their Oxidation to Flavones by Means of Selenium Dioxide.*

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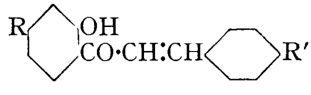
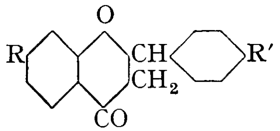
Although resacetophenone does not react with benzaldehyde in presence of alkali to yield the chalkone (contrast Ellison, J., 1927, 1720; see also Shinoda and Sato, *J. Pharm. Soc. Japan*, 1928, **48**, 109), its 4-benzyl ether (Gulati, Seth, and Venkataraman, J., 1934, 1765) readily gives chalkones (I, R = $O{\cdot}CH_2Ph$) with benzaldehyde, anisaldehyde, *p*-benzyloxybenzaldehyde, and 3 : 4-dibenzyloxybenzaldehyde; a free hydroxyl is thus permissible in the ortho-position to the ketonic group. Debenzylation of the compounds to polyhydroxychalkones was not feasible, except in the first case, where a small amount of 2 : 4-dihydroxychalkone (Shinoda and Sato, *loc. cit.*) was obtained. Treatment with phosphoric acid in alcohol (Dean and Nierenstein, *J. Amer. Chem. Soc.*, 1925, **47**, 1680) gave the flavanones (II), which could be debenzylated in the usual way.

2 : 3-Dihydro-β-naphthaflavone (III) gave with selenium dioxide in xylene the naphthaflavone and not the naphthaflavonol, though this oxidising agent is specific for the conversion of CH_2 into CO (Müller, *Ber.*, 1933, **66**, 1668; Evans, Ridgion, and Simonsen, J., 1934, 137; Chakravarti and Swaminathan, *J. Indian Chem. Soc.*, 1934, **9**, 715). *o*-Hydroxy-

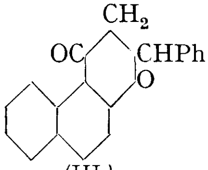
chalkones (I) themselves are smoothly converted into flavones by selenium dioxide. Algar and Flynn (*Proc. Royal Irish Acad.*, 1934, Ser. B, 42, separate issue) have shown that



(I.)



(II.)



(III.)

flavonols are produced by the oxidation of chalkones with alkaline hydrogen peroxide. Flavone, 7-*benzyloxyflavone*, and 7-*benzyloxy*-4′-*methoxyflavone* can be obtained from the appropriate chalkones. The two benzyl ethers were unaffected by hydrochloric acid in acetic acid; hydrobromic acid effected debenzylation, but the product from the latter ether was 7 : 4′-dihydroxyflavone, not pratol.

The interaction of 1-acetyl-2-naphthol with cinnamaldehyde and alkali produced 3-*styryl*-2 : 3-*dihydro*-1 : 4-βα-*naphthapyrone* (as III), treatment of which with selenium dioxide gave 3-*styryl*-1 : 4-βα-*naphthapyrone*, identical with the substance prepared by the method of Heilbron, Barnes, and Morton (J., 1923, **123**, 2565; see Cheema, Gulati, and Venkataraman, J., 1932, 926).

EXPERIMENTAL.

The chalkones were prepared by method 2 of Mahal and Venkataraman (J., 1933, 617). For conversion into flavanone the chalkone (2 g.) in absolute alcohol (250 c.c.) was treated with phosphoric oxide (11 g.) and water (20 c.c.), and the mixture refluxed for 48—72 hours. After removal of the major portion of the alcohol the separated chalkone was collected; the more soluble flavanone was recovered from the mother-liquor and crystallised from aqueous alcohol until it did not give a ferric chloride coloration.

2-*Hydroxy*-4-*benzyloxyphenyl styryl ketone* formed bright yellow leaflets, m. p. 135°, from alcohol–acetic acid (Found : C, 79·9; H, 5·6. $C_{22}H_{18}O_3$ requires C, 80·0; H, 5·4%). 7-*Benzyloxyflavanone*, thin, very pale yellow leaflets, m. p. 104° after sintering at 102° (Found : C, 79·8; H, 5·5. $C_{22}H_{18}O_3$ requires C, 80·0; H, 5·4%). 2-*Hydroxy*-4-*benzyloxyphenyl* 4-*methoxystyryl ketone*, orange-yellow needles, m. p. 132—133° (Found : C, 76·5; H, 5·3. $C_{23}H_{20}O_4$ requires C, 76·7; H, 5·5%). 7-*Benzyloxy*-4′-*methoxyflavanone*, long, pale yellow needles, m. p. 114° (Found : C, 76·5; H, 5·6. $C_{23}H_{20}O_4$ requires C, 76·7; H, 5·5%). 2-*Hydroxy*-4-*benzyloxyphenyl* 4-*benzyloxystyryl ketone*, stout, bright yellow needles, m. p. 139° (Found : C, 79·8; H, 5·4. $C_{29}H_{24}O_4$ requires C, 79·8; H, 5·5%).

3 : 4-*Dibenzyloxybenzaldehyde*.—Protocatechualdehyde was treated with benzyl chloride and potassium carbonate in acetone, and the excess of benzyl chloride removed by steam-distillation. The oily product crystallised from aqueous alcohol in long, shining, colourless needles, m. p. 93° (Found : C, 79·1; H, 5·7. $C_{21}H_{18}O_3$ requires C, 79·3; H, 5·7%). 2-*Hydroxy*-4-*benzyloxyphenyl* 3 : 4-*dibenzyloxystyryl ketone* formed bright yellow needles, m. p. 137° (Found : C, 79·7; H, 5·6. $C_{36}H_{30}O_5$ requires C, 79·7; H, 5·5%). 2-*Hydroxy*-4-*methoxyphenyl* 4-*benzyloxystyryl ketone*, orange-yellow needles, m. p. 125—126° (Found : C, 76·4; H, 5·5. $C_{23}H_{20}O_4$ requires C, 76·7; H, 5·5%). 7-*Methoxy*-4′-*benzyloxyflavanone*, pale yellow needles, m. p. 98—99° (Found : C, 76·7; H, 5·5. $C_{23}H_{20}O_4$ requires C, 76·7; H, 5·5%).

4′-*Hydroxy*-7-*methoxyflavanone*.—After debenzylation of the last compound by means of hydrochloric acid in acetic acid, the mixture was steam-distilled. The oily residue was taken up in ether, the ethereal solution extracted with 5% aqueous caustic soda, and the alkaline layer acidified and again extracted with ether. Removal of the ether and crystallisation from dilute alcohol gave pale yellow needles, m. p. 160° (Found : C, 71·0; H, 5·2. $C_{16}H_{14}O_4$ requires C, 71·1; H, 5·1%). The alcoholic solution gave a brown colour with ferric chloride.

β-*Naphthaflavone*.—A mixture of β-naphthaflavanone (III) (0·5 g.), selenium dioxide (0·7 g.), and xylene (5 c.c.) was heated at 140—150° (oil-bath) for 5 hours. Selenium dioxide was filtered off and washed with ether. The ether–xylene was extracted with 10% caustic soda solution; acidification of the alkaline layer gave no precipitate. Removal of the ether–xylene and crystallisation of the residue from alcohol gave β-naphthaflavone, m. p. 163°, undepressed by admixture with an authentic specimen (Menon and Venkataraman, J., 1931, 2592).

Flavone.—*o*-Hydroxyphenyl styryl ketone (3 g.), selenium dioxide (3 g.), and amyl alcohol

(30 c.c.) were heated (oil-bath at 150°) under reflux for 12 hours. After removal of the selenium and its washing with ether, the ether–amyl alcohol solution was extracted with 10% aqueous caustic soda; nothing was obtained by acidification of the alkaline layer. Ether and amyl alcohol were removed by steam-distillation; the pale brown, oily residue crystallised from petroleum (b. p. 50—60°) in long colourless needles (1·3 g.) of flavone, m. p. 99°.

7-*Benzyloxyflavone.*—2-Hydroxy-4-benzyloxyphenyl styryl ketone (2 g.) was oxidised as in the previous case, the selenium filtered off, and amyl alcohol removed by steam-distillation. The residual solid crystallised from aqueous acetic acid in long colourless needles (0·7 g.), m. p. 187° (Found: C, 80·3; H, 4·6. $C_{22}H_{16}O_3$ requires C, 80·5; H, 4·9%). Debenzylation (Gulati, Seth, and Venkataraman, *loc. cit.*) with acetic acid and hydrobromic acid saturated at 0° gave colourless needles of 7-hydroxyflavone, m. p. 240° (Found: C, 75·6; H, 4·4. Calc. for $C_{15}H_{10}O_3$: C, 75·6; H, 4·2%).

7-*Benzyloxy*-4′-*methoxyflavone.*—The oxidation and isolation were effected as in the previous case. Two crystallisations from alcohol gave yellow needles, m. p. 137° (Found: C, 76·9; H, 5·0. $C_{23}H_{18}O_4$ requires C, 77·1; H, 5·0%). Treatment with hydrobromic acid in acetic acid and addition of water gave a gelatinous precipitate, which was collected and crystallised from 50% acetic acid. The pale yellow needles obtained melted at 310—311° (Kostanecki and Osius, *Ber.*, 1899, **32**, 321, give m. p. 315°) (Found: C, 70·6; H, 3·7. Calc. for $C_{15}H_{10}O_4$: C, 70·9; H, 3·9%). The other properties of the product were similar to those described by Kostanecki and Osius for 7 : 4′-dihydroxyflavone; pratol (Robinson and Venkataraman, J., 1926, 2346) melts at 262°.

3-*Styryl*-2 : 3-*dihydro*-1 : 4-βα-*naphthapyrone.*—A mixture of 1-acetyl-2-naphthol (5 g.), cinnamaldehyde (3·7 g.), absolute alcohol (50 c.c.), and 50% caustic soda solution (10 g.) was kept for 48 hours and then poured into water. The precipitate was washed with water and twice crystallised from alcohol, giving colourless woolly needles (4·2 g.), m. p. 144° (Found: C, 84·1; H, 5·1. $C_{21}H_{16}O_2$ requires C, 84·0; H, 5·3%). They developed no coloration with alcoholic ferric chloride.

3-*Styryl*-1 : 4-βα-*naphthapyrone.*—(1) The hydrolysis of 2-acetyl-3-methyl-1 : 4-βα-naphthapyrone (Menon and Venkataraman, *loc. cit.*) was most conveniently carried out by boiling with 5% sodium carbonate solution for 2 hours. The 3-methyl-1 : 4-βα-naphthapyrone obtained condensed with benzaldehyde in presence of alcoholic sodium ethoxide to give the 3-*styryl* compound, very pale yellow, woolly needles from alcohol, m. p. 200° (Found: C, 84·4; H, 4·5. $C_{21}H_{14}O_2$ requires C, 84·5; H, 4·7%). The substance was coloured deep yellow by sulphuric acid and the yellow solution exhibited a bright green fluorescence. (2) Oxidation of 3-styryl-2 : 3-dihydro-1 : 4-βα-naphthapyrone (0·3 g.) with selenium dioxide was effected in xylene solution, the method of isolation following the instance of β-naphthaflavone. One crystallisation from alcohol–acetic acid gave very pale yellow needles (0·1 g.), m. p. 200°, undepressed by admixture with the previous specimen.

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