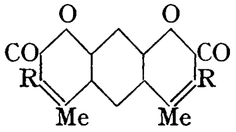
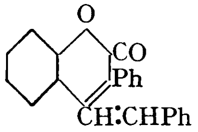
154. *Some 4-Styrylcoumarins.*

By Harbhajan S. Mahal and Krishnasami Venkataraman.

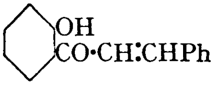
During an investigation of the action of acid anhydrides on phenolic ketones (Venkataraman and others, J., 1929, 2219, *et seq.*; Gulati and Venkataraman, J., 1931, 2376) it appeared possible to prepare dicoumarins (I) and 4-styrylcoumarins (II) by an application of this process. By heating 4 : 6-diacetylresorcinol in acetic anhydride with sodium phenylacetate and with sodium *p*-nitrophenylacetate, the 3 : 3′-diphenyl and the 3 : 3′-di-*p*-nitrophenyl derivative of (I) were respectively obtained; in view of the work of Algar, O'Reilly, and Joy (*Proc. Roy. Irish Acad.*, 1932, **41**B, 1) on identical lines, further experiments on dicoumarins have not been described. The action of sodium phenylacetate and acetic anhydride under prescribed conditions on derivatives of *o*-hydroxyphenyl styryl ketone (III) gave the corresponding derivative of 3-phenyl-4-styrylcoumarin (II); similarly from 2-cinnamoyl-1-naphthol (IV) and its derivatives the corresponding 3-phenyl-4-styryl-1 : 2-α-naphthapyrones (V) were obtained. The initial chalkones were prepared by a modification of v. Kostanecki's method. Neither with 4 : 6-diacetylresorcinol nor with *o*-hydroxy-chalkones could the coumarins unsubstituted in the 3-position be prepared by this method; the action of sodium acetate and acetic anhydride on (III) under widely varying conditions (using, *e.g.*, iodine as catalyst; cf. Yanagisawa and Kondo, *J. Pharm. Soc. Japan*, 1921, **472**, 498) led to an uncrystallisable oil; with certain other chalkones the acetyl derivative was isolated. Similar negative results were obtained with sodium propionate. The formation of (II) must therefore be attributed to the reactivity of the methylene group in sodium phenylacetate. 4-*Styrylcoumarin*, the parent member of the series, was finally prepared according to Dey and Row (*J. Indian Chem. Soc.*, 1924, **1**, 107, 277) by condensing coumaryl-4-acetic acid (Limaye, *ibid.*, 1927, **4**, 159) with benzaldehyde. Although coumaryl-4-acetic acids are extremely reactive towards aldehydes, under no conditions would 4-methylcoumarin and 3-*phenyl*-4-*methylcoumarin* (the latter prepared by heating *o*-hydroxyacetophenone with sodium phenylacetate and acetic anhydride) interact with an aldehyde.



(I.)

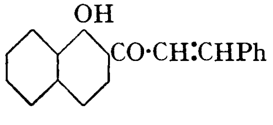


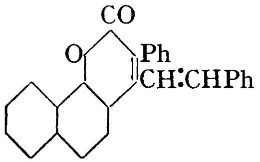
(II.)



(III.)

(IV.)





(V.)

The styrylcoumarins form dibromides with bromine in carbon disulphide; they do not form hydrochlorides, whereas the isomeric 2-styrylchromones readily yield deeply coloured crystalline hydrochlorides (Heilbron, Barnes, and Morton, J., 1923, **123**, 2565; Cheema, Gulati, and Venkataraman, J., 1932, 925).

Experimental.

4 : 6-*Diacetylresorcinol*.—The only method by which consistent yields of the pure substance could be prepared is that described by Gulati and one of us (*loc. cit.*). Treatment of resorcinol diacetate (10 g.) with $AlCl_3$ (20 g.) and nitrobenzene (15 c.c.) on the water-bath (Wittig, *Annalen*, 1926, **446**, 184) led only to resacetophenone (5 g.), needles (from C_6H_6), m. p. 142°.

3 : 3′-*Diphenyl*-4 : 4′-*dimethyldicoumarin* (I; R = Ph).—A mixture of 4 : 6-diacetylresorcinol (3·0 g.), sodium phenylacetate (5·0 g.), and Ac_2O (40 g.) was refluxed for 30 hr. The oil pptd. by H_2O solidified and after two crystns. from pyridine and one from AcOH gave pale yellow

needles, m. p. 276° (Algar *et al.* give 276—277°) (Found : C, 79·1; H, 4·6. Calc. for $C_{26}H_{18}O_4$: C, 79·2; H, 4·6%). The pale yellow solution in H_2SO_4 has a distinct green fluorescence.

3 : 3′-Di-*p*-nitrophenyl-4 : 4′-dimethyldicoumarin (I; R = $C_6H_4{\cdot}NO_2$), twice cryst. from pyridine, gave yellow plates, decomp. *ca.* 325° after sintering at 310° (Algar *et al.*, above 330°) (Found : N, 5·7. Calc. for $C_{26}H_{16}O_8N_2$: N, 5·8%). The bright yellow solution in H_2SO_4 exhibits a faint green fluorescence.

4-*Styrylcoumarin*.—A mixture of coumaryl-4-acetic acid (1·0 g.), benzaldehyde (0·5 g.), pyridine (5 g.), and piperidine (5 drops) was heated on a water-bath for 2 hr. and then at 150° for 2 hr. Cold H_2O (10 c.c.) was added to the deep orange mixture; the separated semi-solid mass solidified 12 hr. after the addition of a few drops of conc. HCl and then crystallised from EtOH in long colourless needles (0·3 g.), m. p. 143° (Found : C, 82·0; H, 4·9. $C_{17}H_{12}O_2$ requires C, 82·2; H, 4·8%), insol. in Na_2CO_3 aq. and giving a bright yellow non-fluorescent solution in H_2SO_4.

Chalkones.—(1) A solution of the ketone and the aldehyde (1 mol. of each) in the min. quantity of hot aldehyde-free EtOH was, after addition of a 50% solution of NaOH (twice the wt. of the ketone), boiled on the water-bath for 1 hr. and poured into H_2O; the product was washed and crystallised from aq. AcOH. The following chalkones were thus prepared : 2-hydroxyphenyl 3 : 4-methylenedioxystyryl ketone (VI), 2-hydroxy-3 : 4-dimethoxyphenyl 4-methoxystyryl ketone (VII), 2-hydroxy-3 : 4-dimethoxyphenyl 3 : 4-methylenedioxystyryl ketone (VIII), 2-cinnamoyl-1-naphthol (IX), 2-*p*-methoxycinnamoyl-1-naphthol (X), and 2-(3′ : 4′-methylenedioxy)cinnamoyl-1-naphthol (XI).

(2) As (1) but at room temp. after 12 hr., ice and HCl aq. were added to the solid mass and the product was crystallised from aq. EtOH. 2-Hydroxyphenyl styryl ketone (XII) and 2-hydroxyphenyl 4-methoxystyryl ketone (XIII) were thus prepared.

3-*Phenyl*-4-*styrylcoumarins*.—These were prepared by heating the appropriate chalkone (1 mol.), sodium phenylacetate (1 mol.), and a large excess of Ac_2O during 24—48 hr. and pouring the mixture into H_2O. The yields were usually about 25%. The substances are coloured orange to red by H_2SO_4 and the yellow solutions exhibit a distinct blue, green, or bluish-green fluorescence.

3-*Phenyl*-4-*styrylcoumarin* (from XII), colourless rhombic prisms from AcOH, m. p. 174° (Found : C, 85·1; H, 4·8. $C_{23}H_{16}O_2$ requires C, 85·2; H, 4·9%); the *dibromide*, prepared from Br (0·1 g. in CS_2, 2 c.c.) and the substance (0·2 g. in CS_2, 20 c.c.), was freed from the solvent after 24 hr. and crystallised from EtOH–C_6H_6, forming colourless rhombohedral prisms, m. p. 198° (Found : Br, 33·0. $C_{23}H_{16}O_2Br_2$ requires Br, 33·1%). 3-*Phenyl*-4-(4′-*methoxystyryl*)-*coumarin* (from XIII), yellow needles, m. p. 170°, from AcOH (Found : C, 81·6; H, 5·0. $C_{24}H_{18}O_3$ requires C, 81·4; H, 5·0%). 3-*Phenyl*-4-(3′ : 4′-*methylenedioxystyryl*)*coumarin* (from VI) solidified after long standing in contact with EtOH–AcOH and after two crystns. from 90% AcOH formed yellow needles, m. p. 172° (Found : C, 78·3; H, 4·3. $C_{24}H_{16}O_4$ requires C, 78·3; H, 4·3%). 7 : 8-*Dimethoxy*-3-*phenyl*-4-(4′-*methoxystyryl*)*coumarin* (from VII), yellow needles from AcOH, m. p. 195° (Found : C, 75·3; H, 5·0. $C_{26}H_{22}O_5$ requires C, 75·4; H, 5·3%). 7 : 8-*Dimethoxy*-3-*phenyl*-4-(3′ : 4′-*methylenedioxystyryl*)*coumarin* (from VIII) formed pale brown needles, m. p. 203°, after two crystns. from AcOH (Found : C, 72·8; H, 4·6. $C_{26}H_{20}O_6$ requires C, 72·9; H, 4·7%). 3-*Phenyl*-4-*styryl*-1 : 2-α-*naphthapyrone* (from IX), pale yellow needles from MeOH, m. p. 210° (Found : C, 86·6; H, 4·6. $C_{27}H_{18}O_2$ requires C, 86·5; H, 4·8%). 3-*Phenyl*-4-(4′-*methoxystyryl*)-1 : 2-α-*naphthapyrone* (from X), long yellow needles from EtOH–AcOH, m. p. 196° (Found : C, 83·3; H, 4·9. $C_{28}H_{20}O_3$ requires C, 83·2; H, 4·9%). 3-*Phenyl*-4-(3′ : 4′-*methylenedioxystyryl*)-1 : 2-α-*naphthapyrone* (from XI), yellow needles from EtOH–AcOH, m. p. 215° (Found : C, 80·2; H, 4·4. $C_{28}H_{18}O_4$ requires C, 80·3; H, 4·3%).

3-*Phenyl*-4-*methylcoumarin*.—*o*-Hydroxyacetophenone (2·0 g.), sodium phenylacetate (2·3 g.), and Ac_2O (25 c.c.) were refluxed for 30 hr. The substance pptd. by H_2O crystallised from EtOH in very pale brown, long, silky needles (1·5 g.), m. p. 153° (Found : C, 81·3; H, 5·2. $C_{16}H_{12}O_2$ requires C, 81·4; H, 5·1%).

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FORMAN CHRISTIAN COLLEGE, LAHORE.

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