# CLXXVII.—*Styrylpyrylium Salts. Part XIII. The Reactivity of Methyl β-Phenylethyl and Methyl γ-Phenylpropyl Ketones.*

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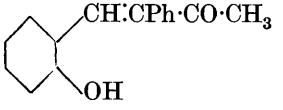
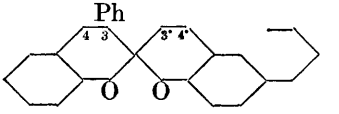
In a previous communication (Heilbron and Irving, J., 1929, 936) proof was adduced showing that, when benzyl methyl ketone is condensed with salicylaldehyde in presence of piperidine, the methylene and not the methyl group is the reactive one. This conclusion was reached as a result of the application of the benzo-β-naphtha-*spiro*pyran colour change, since the *spiro*pyran (II) obtained by condensing the reaction product (I) with 2-naphthol-1-aldehyde undergoes intramolecular ionisation in hot high-boiling inert solvents to give a coloured solution and must therefore be unsubstituted in the 3′-position (compare Dickinson and Heilbron, J., 1927, 1699).

(I.) 

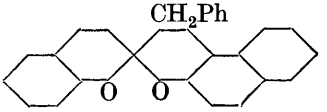
(II.)

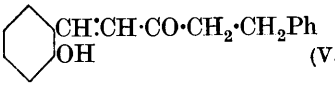
This abnormal behaviour is undoubtedly caused by the increased activation of the methylene due to the directly attached phenyl group. It is thus to be anticipated that with methyl β-phenylethyl ketone (III) and methyl γ-phenylpropyl ketone (IV), where electronic effects due to phenyl will be almost wholly neutralised by the lengthening of the saturated chain, a reversion to normal type would ensue. As shown by the following experimental results, this anticipation has been fully realised.

(III.) $Ph\cdot CH_2\cdot CH_2\cdot COMe$ $Ph\cdot[CH_2]_3\cdot COMe$ (IV.)

When methyl β-phenylethyl ketone is condensed with salicylaldehyde in presence of piperidine, an unsaturated ketone is obtained which, when further condensed with 2-naphthol-1-aldehyde, leads to a substituted benzo-β-naphtha*spiro*pyran; this shows no colour on heating, and consequently must have the structure (VI). It follows that the unsaturated ketone itself must be 2-*hydroxystyryl* β-*phenylethyl ketone* (V), and hence in (III), unlike the case of benzyl

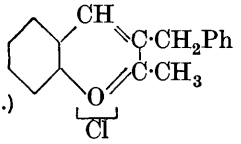
methyl ketone, the methyl group and not the methylene is reactive in presence of piperidine. The same result is obtained when sodium hydroxide is employed—a further distinction from the behaviour of benzyl methyl ketone, which condenses with salicylaldehyde in presence of this reagent to give substances of very complex character (Dickinson, J., 1926, 2234).

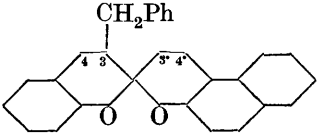
(VI.) 



(V.)

When methyl β-phenylethyl ketone is condensed with salicylaldehyde in presence of dry hydrogen chloride, a different result is obtained. The pyrylium salt formed reacts with 2-naphthol-1-aldehyde to give a benzo-β-naphtha*spiro*pyran which readily produces a purple colour in boiling xylene solution. This isomeric *spiro*pyran must therefore be 3-benzylbenzo-β-naphtha*spiro*pyran (VIII), and the simple pyrylium salt from which it is derived must have the structure (VII) and arise as a result of the methylene group entering into reaction.

(VII.) 


(VIII.)

Similar results have been obtained by condensing salicylaldehyde with methyl γ-phenylpropyl ketone (IV). When sodium hydroxide is used, 2-*hydroxystyryl γ-phenylpropyl ketone* is formed, from which 3′-*phenylethylbenzo*-β-*naphtha*spiro*pyran* results. On the other hand, the use of hydrogen chloride leads to the formation of the isomeric 3-*phenylethylbenzo*-β-*naphtha*spiro*pyran*. In addition to the *spiro*pyrans already mentioned, 3-benzyldibenzo*spiro*pyran, 3-benzyldi-β-naphtha*spiro*pyran, and 3-*phenylethyldi*-β-*naphtha*spiro*pyran* have been prepared: these are normal in their properties, both dinaphtha*spiro*pyrans giving the colour change, and the dibenzo-compound failing to do so.

*Dimerides.*—A study has been made of the condensation products from methyl β-phenylethyl ketone and methyl γ-phenylpropyl ketone and benzaldehyde. From the former, styryl β-phenylethyl ketone (IX) is readily obtained in aqueous-alcoholic solution in

$CHPh{:}CH{\cdot}CO{\cdot}CH_2{\cdot}CH_2Ph$ (IX.) $CHPh{:}CH{\cdot}CO{\cdot}CH(CH_2Ph){\cdot}CO_2H$ (X.)

presence of alkali (compare Harries, *Annalen*, 1904, **330**, 233). Its structure has now been definitely established by its preparation

from *benzylidene-α-benzylacetoacetic acid* (X). By the use of more concentrated alkali and with a minimum quantity of water the high-melting *di(styryl β-phenylethyl ketone)* is obtained in place of the unimolecular compound.

Methyl γ-phenylpropyl ketone reacts similarly towards benzaldehyde, *styryl γ-phenylpropyl ketone* or its *dimeride* being formed according to the experimental conditions.

The formation of these dimerides is similar to that previously recorded with many styryl alkyl ketones (Heilbron and Irving, J., 1929, 931). In this respect benzyl methyl ketone again differs from the ketones under review, as it fails to yield a simple cyclic dimeric derivative (Goldschmiedt and Knöpfer, *Monatsh.*, 1897, **18**, 438; 1898, **19**, 413).

## EXPERIMENTAL.

*Methyl β-Phenylethyl Ketone.*—This compound, previously prepared by Harries (*loc. cit.*) by the reduction of styryl methyl ketone with sodium amalgam, is readily obtained from ethyl α-benzylacetoacetate : The ester (30 g.) was refluxed for 6 hours with 20% aqueous sodium hydroxide (210 g.) and after the cold solution had been saturated with salt the ketone was extracted with ether, dried, and distilled under reduced pressure, the fraction b. p. 122—124°/16 mm. being collected (yield, 18 g.) (compare Mattar, Hastings, and Walker, J., 1930, 2455).

Styryl β-phenylethyl ketone (IX), prepared by the method of Harries (*loc. cit.*), separated from methyl alcohol in colourless plates, m. p. 53—54° (Mattar, Hastings, and Walker give 56°). The *semicarbazone* separated from alcohol in colourless crystals, m. p. 135°, which became bright yellow on exposure to light (Found : N, 14·5. $C_{18}H_{19}ON_3$ requires N, 14·4%).

*Benzylidene-α-benzylacetoacetic Acid* (X).—A suspension of benzaldehyde (7 g.) and ethyl α-benzylacetoacetate (14 g.) in water (200 c.c.) was shaken continuously for 11 days, aqueous sodium hydroxide (30 c.c. of 8%) being added in six equal portions during this period. After removal of unchanged reactants with ether, the aqueous layer was separated and rendered acid, and the crude material purified by repeated crystallisation from absolute alcohol. *Benzylidene-α-benzylacetoacetic acid* formed colourless places, m. p. 157° (decomp.) (Found : C, 77·0; H, 5·7. $C_{18}H_{16}O_3$ requires C, 77·1; H, 5·7%). When the acid was heated in presence of copper powder at 160°, styryl β-phenylethyl ketone, m. p. 53° (from methyl alcohol), was formed.

*Di(styryl β-phenylethyl ketone).*—A solution of benzaldehyde (6 g.) and methyl β-phenylethyl ketone (9 g.) in absolute alcohol (45 c.c.) was treated with sodium hydroxide solution (3 c.c. of 30%) and kept

at room temperature for 24 hours. The separated solid, after repeated crystallisation from alcohol–ethyl acetate, gave the *dimeride* in fine colourless needles, m. p. 184° (Found : C, 86·4; H, 6·8; *M*, 487. $C_{34}H_{32}O_2$ requires C, 86·4; H, 6·7%; *M*, 472).

2-*Hydroxystyryl* β-*Phenylethyl Ketone* (V).—(a) A solution of salicylaldehyde (9 g.) and methyl β-phenylethyl ketone (10 g.) in alcohol (40 c.c.) was kept together with aqueous sodium hydroxide (50 c.c. of 20%) for 5 days at − 5°; the sodium salt then separated from the orange-coloured solution. The *ketone*, obtained by treatment of an aqueous-alcoholic solution of the salt with carbon dioxide, crystallised from aqueous alcohol in colourless plates, m. p. 128—129° (Found : C, 81·0; H, 6·3. $C_{17}H_{16}O_2$ requires C, 80·9; H, 6·3%).

(b) A solution of salicylaldehyde (5 g.) and methyl β-phenylethyl ketone (6 g.) in alcohol (6 c.c.) was kept at room temperature during 8 weeks, small quantities of piperidine being added at regular intervals. The viscous reaction product was diluted with alcohol and the solution made acid; the ketone, precipitated as a semi-solid mass, after repeated crystallisation from alcohol–light petroleum, yielded the pure substance, m. p. 128—129°.

3-*Benzyldibenzo*spiro*pyran*.—This compound was obtained by Löwenbein and Katz (*Ber.*, 1926, **59**, 1377) by condensing ethyl α-benzylacetoacetate with salicylaldehyde in presence of perchloric acid, followed by hydrolysis of the pyrylium perchlorate. We have now prepared it by hydrolysing the pyrylium chloride which results when salicylaldehyde and methyl β-phenylethyl ketone are condensed in alcoholic solution by means of hydrogen chloride. The compound separated from acetone in small colourless crystals, m. p. 121°.

3-*Benzylbenzo*-β-*naphtha*spiro*pyran* (VIII).—A solution of salicylaldehyde (1·2 g.) and methyl β-phenylethyl ketone (1·5 g.) in glacial acetic acid (6 c.c.) was saturated with hydrogen chloride at 0°. After 8 hours, a solution of 2-naphthol-1-aldehyde (1·7 g.) in glacial acetic acid (5 c.c.) was added, and the whole resaturated with hydrogen chloride. The pyrylium salt which separated over-night at 0° from the deep red purple solution was hydrolysed in ether suspension with dilute aqueous ammonia. The spiro*pyran* obtained by evaporating the dried ethereal solution separated from acetone in small colourless crystals, m. p. 157° (to a purple liquid). Its solution in cold xylene is colourless, but attains an intense reddish-purple colour at the boiling point; in glacial acetic acid a blue colour slowly develops (Found : C, 86·3; H, 5·4. $C_{28}H_{23}O_2$ requires C, 86·6; H, 5·2%).

3′-*Benzylbenzo*-β-*naphtha*spiro*pyran* (VI).—A solution of 2-hydroxystyryl β-phenylethyl ketone (1·3 g.) and 2-naphthol-1-aldehyde (1·7 g.) in alcohol (10 c.c.) was saturated with hydrogen chloride at 0° and kept at the same temperature for 24 hours. The

separated pyrylium salt was hydrolysed with dilute aqueous ammonia in presence of ether. The ethereal extract on evaporation yielded an oil which solidified on treatment with methyl alcohol. The pure spiro*pyran* obtained after crystallisation from acetone formed colourless crystals, m. p. 129—130°, and gave a colourless solution in boiling xylene; in glacial acetic acid a wine-red colour was rapidly produced (Found : C, 86·8; H, 5·2. $C_{28}H_{20}O_2$ requires C, 86·6; H, 5·2%).

3-*Benzyldi*-β-*naphtha*spiro*pyran*.—This compound has also been prepared by Löwenbein and Katz (*loc. cit.*) by hydrolysis of the pyrylium perchlorate resulting from the condensation of ethyl α-benzylacetoacetate with 2-naphthol-1-aldehyde in presence of perchloric acid. We have now obtained the corresponding pyrylium chloride very smoothly by condensing methyl β-phenylethyl ketone with 2-naphthol-1-aldehyde in alcoholic solution with hydrogen chloride. The *spiro*pyran, prepared in the usual manner, separated from acetone–benzene in colourless crystals, m. p. 207° as recorded by the above authors.

*Ethyl* α-(β-*Phenylethyl*)*acetoacetate*.—β-Phenylethyl bromide was prepared either by treating β-phenylethyl alcohol with hydrogen bromide in glacial acetic acid under pressure as described by Schroeter, Lichtenstadt, and Irineu (*Ber.*, 1918, **51**, 1599) or more conveniently by heating the alcohol with the theoretical amount of phosphorus tribromide for 4 hours at 90°.

Phenylethyl bromide (31 g.) was slowly added to ethyl sodioacetoacetate (from 22 g. of the ester) in alcohol (70 c.c.), and the whole heated under reflux for 4 hours. After removal of the alcohol, water was added and the product extracted with ether. After removal of solvent from the dried solution, the ester was distilled, the portion, b. p. 174—176°/18 mm., being collected.

*Methyl γ-Phenylpropyl Ketone* (IV).—This compound has been obtained by Diels and Poetsch (*Ber.*, 1921, **54**, 1585) together with other products by the reduction of benzylidenediacetylmonoxime. It is conveniently prepared by hydrolysing ethyl α-(β-phenylethyl)-acetoacetate in the manner described for the preparation of methyl β-phenylethyl ketone. The pure ketone is an oily liquid, b. p. 128—130°/15 mm.

*Styryl γ-Phenylpropyl Ketone*.—A solution of benzaldehyde (1·1 g.) and methyl γ-phenylpropyl ketone (1·6 g.) in alcohol (5 c.c.) was treated with aqueous potassium hydroxide (5 c.c. of 1·5%), and the whole kept for 24 hours in the ice-chest. The separated solid was crystallised from methyl alcohol, from which pure *styryl γ-phenylpropyl ketone* separated in colourless plates, m. p. 51° (Found : C, 86·4; H, 7·1. $C_{18}H_{18}O$ requires C, 86·4; H, 7·2%).

*Di*(*styryl γ-phenylpropyl ketone*).—The same quantities of benz-

aldehyde and methyl γ-phenylpropyl ketone as were used in the above condensation were dissolved in alcohol (10 c.c.) and the solution after treatment with aqueous sodium hydroxide (0·5 c.c. of 30%) was kept at room temperature for 48 hours. The separated product was crystallised from alcohol–ethyl acetate, from which the pure *dimeride* separated in fine colourless needles, m. p. 138° (Found : C, 86·3; H, 7·1; *M*, 510. $C_{36}H_{36}O_2$ requires C, 86·4; H, 7·2%; *M*, 500).

2-*Hydroxystyryl γ-Phenylpropyl Ketone.*—A solution of salicylaldehyde (3·7 g.) and methyl γ-phenylpropyl ketone (4·9 g.) in alcohol (20 c.c.) was kept for 5 days at 0° together with aqueous sodium hydroxide (25 c.c. of 20%); the sodium salt then separated. This was dissolved in aqueous alcohol, and the crude ketone precipitated with carbon dioxide. 2-*Hydroxystyryl γ-phenylpropyl ketone* crystallised from alcohol in colourless rhombs, m. p. 114° (Found : C, 81·2; H, 6·8. $C_{18}H_{18}O_2$ requires C, 81·2; H, 6·8%).

3-β-*Phenylethylbenzo*-β-*naphtha*spiro*pyran.*—A solution of salicylaldehyde (1·2 g.) and methyl γ-phenylpropyl ketone (1·6 g.) in glacial acetic acid (6 c.c.) was saturated with hydrogen chloride and kept for 5 hours at 0°, 2-naphthol-1-aldehyde (1·7 g.) was then added, and the whole again saturated with hydrogen chloride. After standing over-night at 0°, the pyrylium salt was removed from the deep reddish-purple solution, and the crude *spiro*pyran obtained in the usual manner. 3-β-*Phenylethylbenzo*-β-*naphtha*spiro*pyran* crystallises from acetone in colourless needles which melt to a deep purple liquid at 140—141°. Its solution in cold xylene is colourless but attains an intense purple colour on being heated; in glacial acetic acid a blue colour is slowly developed (Found : C, 86·8; H, 5·7. $C_{29}H_{22}O_2$ requires C, 86·6; H, 5·5%).

3′-β-*Phenylethylbenzo*-β-*naphtha*spiro*pyran.*—This was prepared from 2-hydroxystyryl γ-phenylpropyl ketone (1·3 g.) and 2-naphthol-1-aldehyde (1·7 g.) as described in the case of the analogous 3′-benzylbenzo-β-naphtha*spiro*pyran. It separates from acetone in colourless crystals, m. p. 180°, and gives colourless solutions in either boiling xylene or veratrole; it dissolves in glacial acetic acid to a wine-red solution (Found : C, 86·7; H, 5·8. $C_{29}H_{22}O_2$ requires C, 86·6; H, 5·5%).

3-β-*Phenylethyldi*-β-*naphtha*spiro*pyran.*—A solution of methyl γ-phenylpropyl ketone (1·6 g.) and 2-naphthol-1-aldehyde (3·5 g.) in alcohol (15 c.c.) was saturated with dry hydrogen chloride and maintained at 0° for 24 hours; the pyrylium salt then separated. The spiro*pyran* crystallises from benzene in colourless crystals, m. p. 219—220°, which give a blue-purple solution in boiling xylene (Found : C, 87·2; H, 5·7. $C_{34}H_{24}O_2$ requires C, 87·6; H, 5·3%).

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