

PYRILIUM SALTS DERIVED FROM 4-O-METHYL RESORCYLIC ALDEHYDE

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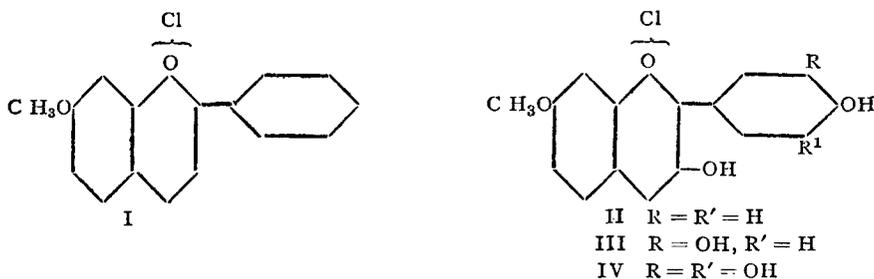
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ALL the naturally occurring anthocyanins were originally considered to be glycosides of three fundamental anthocyanidins, (1) Pelargonidin, (2) Cyanidin and (3) Delphinidin and of certain methyl ethers of (2) and (3) namely Peonidin, Petunidin, Malvidin and Hirsutidin. These are related to the series of flavonols, Kæmferol, Quercetin and Myricetin and the benzo-pyrone part is derived from phloroglucinol. More recent work in this line mainly carried out by Robinson and collaborators has revealed the existence of other possible types, though they may not be so abundant. The flavone type is represented by Gesnerin¹ from *Gesnera fulgens* and Carajurin² from Chica Red. Again tetra-hydroxy benzene nucleus seems to replace the phloroglucinol nucleus in some cases.³ In one of the most interesting group of anthocyanins, the betanin group, which seems to occur more widely than was realised before, nitrogen is found to be present.⁴ The resorcinol nucleus is not uncommon amongst naturally occurring compounds of the benzo-pyrone group. Fisetin, daidzein, formonetin, butin, ψ -baptigenin, equol, umbelliferone, psoralen, and isopsoralen, karanjin, rotenone and its allies may be mentioned as some of the most important of the list. It is possible that this nucleus also finds representation amongst the anthocyanins and a number of reso-anthocyanins have been synthetically obtained by Robinson and his co-workers.⁵

In the course of an investigation on the chemical components of the roots of *Decalepis Hamiltonii*,⁶ considerable amount of 4-O-methyl resorcylic aldehyde was obtained. Further certain resinous and gummy fractions appeared to contain leuco-anthocyanins exhibiting all the well recognised reactions. This aldehyde is found to be widely distributed in nature as the odoriferous principle of various plants and has been isolated in bulk from the roots of *Chlorocodon*,⁷ *Decalepis Hamiltonii*,⁸ *Hemidesmus Indicus*,⁹ *Hanghomia Marseillei* and from the bark of *Periploca græca*.¹⁰ Its wide occurrence suggests the possibility of related anthocyanins or leuco-anthocyanins being discovered in plant materials. It was, therefore, considered to be of interest to prepare pyrilium salts of the anthocyanidin type derived from this aldehyde and record their properties.

For purposes of this investigation, 4-O-methyl resorcylic aldehyde obtained from the roots of *Decalepis Hamiltonii* was employed. This was found to be a convenient source though this aldehyde could also be obtained by synthetic methods.¹¹ It was condensed with (1) acetophenone, (2) ω : 4-dihydroxy-acetophenone, (3) ω : 3: 4-triacetoxy-acetophenone and (4) ω : 3: 4: 5-tetra-acetoxy-acetophenone adopting well known methods developed by Robinson *et al.* The pyrilium salts (I), (II), (III) and (IV) were



obtained in very good yields and they were readily crystallised. Though (I) was prepared by Perkin, Robinson and Turner,¹² a detailed description of its properties is not available and hence an account of it is included in this paper. All the four compounds exhibit strong greenish fluorescence in solution in concentrated sulphuric acid; but on the addition of water the fluorescence persists only in the first two cases, and the appearance of an aqueous solution of (II) exhibits close resemblance to that of an alkaline solution of fluorescein.

In regard to their extractability by amyl alcohol and "Cyanidin Reagent", stability towards the oxidation test and colour reactions with ferric chloride and alkali, compounds (II), (III) and (IV) in general resemble the corresponding anthocyanidin chlorides, pelargonidin, cyanidin and delphinidin. But they exhibit a marked poverty of tinctorial properties when examined with buffer solutions of different pH. This may be attributed to the existence of a methoxyl in the 7-position in place of a hydroxyl and not probably so much to the absence of the 5-hydroxyl. They behave normally in forming pseudo and colour bases.

A solution of compound (I) does not undergo decolorisation on dilution with alcohol or water. In this respect it agrees with other pyrilium salts which do not contain a hydroxyl in the 3-position and consequently do not easily form the ψ -base. However, on the addition of sodium acetate to a solution of the chloride in dilute hydrochloric acid, a coloured crystalline precipitate is obtained which has the semblance of a colour base. But compound (I) cannot form a colour base since it has no hydroxyl group. On

hours, the flask was left in the ice-chest to remain for two days. The contents of the flask were then filtered and the shining red crystalline mass collected. When the filtrate was treated with dry ether (3–4 volumes), only a small quantity of the anthocyanidin chloride could be further isolated. The total yield was 80%. The substance could be crystallised from 1% hydrochloric acid or from 2% methyl alcoholic hydrogen chloride. For purposes of analysis, it was crystallised from the latter when it was obtained in the form of shining red hexagonal prisms melting at 250–51°. (Found: C, 63.2; H, 4.0; OCH₃, 10.0; C₁₆H₁₃O₃Cl requires C, 63.1, H, 4.2 and OCH₃, 10.2%.)

7-Methoxy-3:3':4'-trihydroxy-2-phenyl-benzopyrilium chloride (III) was obtained by condensing 4-O-methyl-resorcylic aldehyde with ω :3:4-tri-acetoxy-acetophenone¹⁵ in a mixture of anhydrous ethyl acetate and ethyl alcohol in equal proportions by means of dry hydrogen chloride according to the method of Bradley, Robinson and Schwarzenbach.¹⁶ At the end of two days the dark red pyrilium salt (yield 85%) was collected from the reaction mixture and crystallised from 1% hydrochloric acid. The pure substance had the form of rectangular plates exhibiting in mass a dark purplish green reflex. It was also obtained crystalline with ease by dissolving it in 1% methyl alcoholic hydrogen chloride and subsequently saturating the solution with dry hydrogen chloride. On allowing the solution to stand in an ice-chest for about 48 hours a light brownish red shining powder possessing a light green reflex settled down. Under the microscope it appeared as groups of spear heads; m.p. 258–60° (decomp.). (Found: C, 58.5, H, 4.4, OCH₃, 8.9; C₁₆H₁₃O₄ Cl, $\frac{1}{2}$ H₂O requires C, 58.3, H, 4.2 and OCH₃, 9.4%.)

7-Methoxy-3:3':4':5'-tetra-hydroxy-2-phenyl-benzo-pyrilium chloride (IV).—This was obtained by condensing, as in the previous case, 4-O-methyl-resorcylic aldehyde with ω :3:4:5-tetra-acetoxy-acetophenone¹⁶ in a mixture of anhydrous ethyl acetate and ethyl alcohol by means of dry hydrogen chloride. A dark red powder (yield 73%) with a dull green reflex was obtained. It was purified by dissolving it in 2% methyl alcoholic hydrogen chloride and then treating the solution with a few drops of concentrated hydrochloric acid. A micro-crystalline powder separated out which showed no tendency to melt even at 340°. It could also be obtained in the form of rectangular plates with a bluish green reflex by crystallisation from dilute hydrochloric acid. (Found: C, 47.3; H, 5.4; OCH₃, 7.3; C₁₆H₁₃O₅Cl, 4H₂O requires C, 47.0; H, 5.1 and OCH₃, 7.6%.)

7-Methoxy-2-phenyl-benzopyrilium chloride (I) was prepared by condensing 4-O-methylresorcylic aldehyde and dry acetophenone in anhydrous ethyl acetate with dry hydrogen chloride (Perkin, Robinson and Turner, *loc. cit.*).

The yellow crystalline mass that was produced rapidly was filtered and washed with ether. The substance (yield 83%) changed, on exposure to light, from yellow to dull brown. It was sparingly soluble in dilute hydrochloric acid in the cold but dissolved freely in the hot acid. On cooling the solution it crystallised as chocolate coloured, shining, prismatic needles melting at 105–06°. (Found: C, 66·3; H, 5·5; OCH₃, 10·6; C₁₆H₁₃O₂Cl, H₂O requires C, 66·1; H, 5·2 and OCH₃, 10·7%.) On the addition of solid sodium acetate in the cold to a fairly strong solution of the pyrilium chloride in dilute hydrochloric acid, a milky white suspension was immediately formed which in the course of a few minutes changed to greenish blue. On leaving it aside for about three to four days, light green shining needles separated out. It was filtered and washed with water. The dry sample melted at 126–28° (decomp.). An alcoholic solution of the substance showed rapid formation of the pyrilium salt on treatment with concentrated hydrochloric acid in the cold. A mixed melting point determination with the synthetic chalkone (see below) did not show any depression.

A solution of the pyrilium chloride (0·1 g.) in glacial acetic acid (1 c.c.) was added to a large volume of water (250 c.c.). At first the solution was clear exhibiting the characteristic green fluorescence but in a few minutes it became turbid. After 24 hours the precipitated solid was filtered. Shining light green needle-shaped crystals were obtained which melted at 126–28° and showed no depression in melting point when mixed either with the synthetic chalkone or with that obtained from the pyrilium chloride on treatment with sodium acetate. The formation of the pyrilium chloride from this sample was also noticed even in the cold on the addition of concentrated hydrochloric acid. (Found: C, 75·5; H, 5·5; OCH₃, 12·0; C₁₆H₁₄O₃ requires C 75·6, H 5·5 and OCH₃ 12·5%.)

Phenyl-4-methoxy-2-hydroxy-styrylketone.—A solution of 4-O-methyl resorcylic aldehyde (0·4 g.), acetophenone (0·4 g.) and potassium hydroxide (2 g.) in methyl alcohol (50 c.c.) was refluxed for about three hours. The deep red solution was added to water rendered acidic by the addition of hydrochloric acid, whereby the unsaturated ketone separated out as a fine yellow powder. It crystallised from aqueous alcohol in the form of yellow rectangular needles melting at 126–28°. (Found: C, 75·5; H, 5·9; OCH₃, 12·1; C₁₆H₁₄O₃ requires C, 75·6; H, 5·5 and OCH₃, 12·5%.) The yellow alcoholic solution of the chalkone on treatment with a few drops of concentrated hydrochloric acid turned orange red and exhibited the characteristic green fluorescence on dilution with water.

The following table gives a summary of the reactions given by the above anthocyanidin chlorides.

	I	II	III	IV
1. 1% HCl	Yellow, bright green fluorescence.	Bright orange red, no fluorescence.	Dark red with a violet tinge, no fluorescence.	Deep violet, no fluorescence.
2. Alcohol	Orange red, no fluorescence, stable and colour is not lost on standing or dilution.	Bright orange red, green fluorescence, lost on standing or dilution.	Dark crimson red, lost on standing or dilution, no fluorescence.	Dark reddish violet, lost on standing or dilution, no fluorescence.
3. Concentrated H ₂ SO ₄	Deep green fluorescence unaffected by dilution.	Bright green fluorescence resembling alkaline solutions of fluorescein, not affected by dilution.	Weak green fluorescence destroyed by dilution.	Slight green fluorescence destroyed by dilution.
4. Extractability with Cyanidin Reagent ¹⁷	Complete.	Complete.	Only partially extracted.	Very slight extraction.
5. Colour base formation.	Light green precipitate of chalkone.	Orange brown colour base.	Blue colour base.	Blue colour base.
6. Ferric reaction. ¹⁷	Negative.	Negative.	Bright blue.	Bright blue.
7. Oxidation Test. ¹⁷	Not stable.	Fairly stable.	Not quite stable.	Not stable.

Colour Reactions

The colour reactions of the anthocyanidin chlorides have been studied with a range of buffered solutions and a few others and the results recorded below. Since small changes in pH did not have any marked effect, differences of 1·2 in pH have been adopted between successive solutions (*cf.* Robertson and Robinson¹⁸). The nature of the various solutions is given below: (1) 1% HCl, (2) 20% HCl, (3) pH 3·2, (4) pH 4·4, (5) pH 5·6, (6) pH 6·8, (7) pH 8·0, (8) pH 9·2, (9) pH 10·4, (10) pH 11·6, (11) pH 12·8, (12) sodium acetate, (13) NaHCO₃, (14) Na₂CO₃ and (15) NaOH. All the buffer solutions were prepared from the B.D.H. Universal Buffer Mixture.

The anthocyanidin chloride solution was prepared by dissolving the pure substances (25·0 mg.) in absolute alcohol (100 c.c.) in a measuring flask and 1 c.c. of the solution added from a burette to 10 c.c. of the buffered solutions or of the other solutions mentioned above.

7-Methoxy-2-phenyl-benzo-pyrylium chloride.—The solution is stable and coloured deep red. (1) Pale orange red; (2) orange red; brighter than in the previous case; (3) pale orange red slightly fluorescent; (4) pale orange red; (5), (6) and (7) from pale blue to blue; (8) and (9) immediately yellow; (10) and (11) yellowish green; (12) blue; (13) dirty greenish blue; (14) greensih yellow; (15) immediately yellow. *After 10 minutes:* (1) to (4) orange red to pale red; (5) to (7) pale blue to blue; (8) and (9) yellow; (10) and (11) greenish yellow; (12) and (13) pale blue; (14) and (15) pale yellow to yellow. *After 30 minutes:* (1) to (4) no change; (5) to (7) pale blue to blue; (8) to (11) increasing intensity of yellow; (12) and (13) pale blue; (14) and (15) yellow. *After 24 hours:* (1) and (2) orange red; (3) very pale red; (4) almost colourless; (5) and (6) pale blue; (7) greenish yellow; (8) to (11) yellow; (12) pale blue; (13) to (15) yellow.

7-Methoxy-3:4'-dihydroxy-2-phenyl-benzo-pyrylium chloride.—The solution at first was purple in colour which soon faded to yellow exhibiting a fine green fluorescence. (1) Very pale red, no marked fluorescence; (2) red solution with green fluorescence; (3) just as (1); (4) to (7) almost colourless, only a very faint red; (8) pale reddish violet; (9) violet red; (10) and (11) violet red, fading rapidly; (12) and (13) colourless at first but slowly reddish violet; (14) violet red; (15) immediately yellow. *After 10 minutes:* (1) almost colourless and turbid; (2) pale yellow with a pale green fluorescence; (3) to (6) pale yellow to pale reddish brown; (7) to (9) violet red; (10) pale yellowish brown; (11) pale violet red; (12) bright reddish violet; (13) almost colourless; (14) pale yellowish brown; (15) pale yellow. *After 30 minutes:* (1) colourless and turbid; (2) pale yellow; (3) to (5) almost colourless; (6) very pale red;

(7) and (8) violet red; (9) to (11) pale yellow; (12) bright reddish violet; (13) to (15) pale yellow. *After 24 hours*: (1) almost colourless, but turbid; (2) orange red; (3) to (11) pale yellow to yellow; (12) very pale yellow; (13) to (15) yellow.

7-Methoxy-3: 3': 4'-trihydroxy-2-phenyl-benzo-pyrilium chloride.--The solution was originally deep purple, but in the course of a few minutes changed to a pale yellow colour. (1) and (2) bright red; (3) very pale red; (4) violet rapidly fading to pale violet; (5) to (8) almost colourless after shaking; (9) to (11) weak blue fading rapidly in the last case; (12) to (14) pale blue; (15) immediately pale yellow. *After 10 minutes*: (1) to (3) keep colour; (4) to (9) colourless to pale blue; (10) and (11) pale yellow; (12) and (13) pale blue; (14) and (15) pale yellow. *After 30 minutes*: (1) to (3) keep colour; (4) to (7) increasing intensity of blue; (8) to (11) from pale yellow to yellow; (12) and (13) blue; (14) and (15) yellow; *After 24 hours*: (1), and (2) keep the bright red colour; (3) pale violet; (4) almost colourless; (5) and (6) pale blue; (7) to (11) yellow; (12) pale blue; a slight blue precipitate collected at the bottom probably because of colour base formation; (13) to (15) pale yellow to yellow.

7-Methoxy-3: 3': 4' : 5'-tetra-hydroxy-2-phenyl-benzopyrilium chloride—The solution is deep purple in colour and a slight change in intensity has only been noticed during the course of the study of colour reactions. (1) and (2) bright red; (3) violet red rapidly fades away to pale violet red; (4) to (7) at first deep violet, but rapidly fade to pale violet; (8) violet-blue, slowly fading; (9) deep blue; (10) and (11) at first deep blue, but fade away to pale brown; (12) and (13) deep pure blue; (14) blue at first, soon changes to yellowish brown; (15) immediately brown. *After 10 minutes*: (1) and (2) keep colour; (3) pale violet red; (4) pale reddish blue; (5) pale violet blue; (6) and (7) violet; (8) and (9) pale blue; (10) and (11) pale yellow; (12) and (13) blue; (14) and (15) pale yellow. *After 30 minutes*: (1) and (2) keep colour; (3) pale violet red; (4) to (7) from pale violet blue to pale violet; (8) pale blue; (9) to (11) yellow; (12) and (13) blue; (14) and (15) yellow. *After 24 hours*: (1) and (2) keep the colour; in both cases a red precipitate settled at the bottom; (3) and (4) almost colourless; a violet blue precipitate settled at the bottom; (5) and (6) only a pale blue colour; (7) to (11) pale yellow to yellow; (12) almost colourless, a blue precipitate at the bottom; (13) pale yellow, a bluish brown precipitate at the bottom; (14) pale yellow; (15) yellow.

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Summary

4-O-methyl ether of resorcylic aldehyde has been condensed with (I) acetophenone, (II) ω :4-dihydroxy acetophenone, (III) ω :3:4-triacetoxy- and (IV) ω :3:4:5 tetra-acetoxy-acetophenone to form pyrilium salts. Their properties and reactions are described. The first compound which has no hydroxyl groups in it undergoes change into the corresponding chalkone when its solution is treated with sodium acetate or when largely diluted with water. The reverse reaction takes place also rapidly in acid solution. The other compounds resemble closely pelargonidin, cyanidin and delphinidin though they exhibit a comparatively marked poverty of colour in solutions.

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