CCCLXI.—*Synthetical Experiments in the Chromone Group. Part IV. 1 : 4-βα-Naphthapyrones.*

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It was shown by Bhullar and one of us (this vol., p. 1165) that 2-acetyl-1-naphthol reacts readily with acid anhydrides to form mixtures of γ-pyrones and their 3-acyl derivatives, the production of the latter, not usually obtained with ketones of the benzene series, being a remarkable feature of the reaction. The action of acid anhydrides on 1-acetyl-2-naphthol has now been studied.

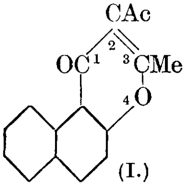
Acetic anhydride and sodium acetate gave only 2-acetyl-3-methyl-1 : 4-βα-naphthapyrone (I), and aromatic anhydrides gave naphthaflavones unsubstituted in the 2-position. It is known that resacetophenone reacts with acetic anhydride to give the 3-acylated chromone (Tahara, *Ber.*, 1892, **25**, 1302; Nagai, *ibid.*, p. 1287; von Kostanecki and Rozycki, *Ber.*, 1901, **34**, 102), and with benzoic and anisic anhydride to give 7-hydroxyflavone and 7-hydroxy-4′-methoxyflavone respectively (Robinson and Venkataraman, J., 1926, 2345). (I) has previously been prepared by Schneider and Kunau (*Ber.*, 1921, **54**, 2302) by heating β-naphthyl methyl ether with sulphoacetic acid; as described by them, on treatment with alcoholic ammonia it gave the 3-methylnaphthapyrone (II; R = Me).

On heating 1-acetyl-2-naphthol with benzoic, anisic, and trimethylgallic anhydride respectively, together with the appropriate sodium salt, βα-naphthaflavone (II; R = Ph), *4′-methoxy-βα-naphthaflavone* (II; R = $C_6H_4{\cdot}OMe$), and *3′ : 4′ : 5′-trimethoxy-βα-naphthaflavone* [II; R = $C_6H_2(OMe)_3$] were obtained. 1-Acetyl-2-naphthol was found in every case to be less reactive than 2-acetyl-1-naphthol; there was no 2-acylation and the yields of the pyrones were comparatively poor. βα-Naphthaflavone has been described by Tambor, Plattner, and Zuch (*Helv. Chim. Acta*, 1926, **9**, 463), who used the bromoflavanone method.

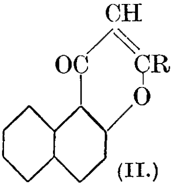
Tambor and others (*loc. cit.*) found that the interaction of 1-acetyl-2-naphthol with benzaldehyde led directly to the flavanone; 2-acetyl-1-naphthol behaves normally with aldehydes (von Kostanecki, *Ber.*, 1898, **31**, 705; 1899, **32**, 1034; Bhullar and Venkataraman, *loc. cit.*), the chalkones being formed. We have treated 1-acetyl-2-naphthol with anisaldehyde, veratraldehyde, and piperonal and obtained in each instance the corresponding *flavanone* [III; R = $C_6H_4{\cdot}OMe$, $C_6H_3(OMe)_2$, or $C_6H_3{:}O_2CH_2$], no trace of a chalkone being formed as shown by the absence of a ferric chloride coloration and the inability to form an acetyl derivative. The usual method of converting the flavanone into the flavone by bromination and treatment with alkali (von Kostanecki, Levi, and Tambor, *Ber.*, 1899, **32**, 326) presented difficulties in the case of our naphthapyranones; but on boiling them with phosphorus pentachloride in benzene (compare Lowenbein, *Ber.*, 1924, **57**, 1515; Hattori, *Bull. Chem. Soc. Japan*, 1927, **2**, 171) the naphthaflavones [II; R = $C_6H_4{\cdot}OMe$, $C_6H_3(OMe)_2$, or $C_6H_3{:}O_2CH_2$] were obtained. The first was identical with the product of the action of anisic anhydride on 1-acetyl-2-naphthol.

Demethylation of 4′-methoxy-βα-naphthaflavone and 3′ : 4′-

*dimethoxy-*βα-*naphthaflavone* respectively gave 4′-*hydroxy-*βα-*naphthaflavone* (II; R = C_6H_4·OH) and 3′ : 4′-*dihydroxy-*βα-*naphthaflavone* [II; R = $C_6H_3(OH)_2$]. The colour reactions of the substances are detailed, but the dyeing properties will be recorded later, together with those of other hydroxynaphthaflavones.



(I.)



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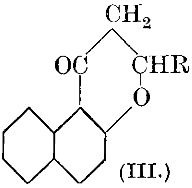

(III.)

The interaction of 1-acetyl-2-naphthol with ethyl formate and sodium and ring closure of the oxymethylene ketone by means of alcoholic sulphuric acid led to 1 : 4-βα-*naphthapyrone* (II; R = H), the parent member of the series.

EXPERIMENTAL.

1 : 4-βα-*Naphthapyrone* (II; R = H).—To an ice-cooled suspension of sodium wire (3 g.) in dry ether (50 c.c.), a mixture of 1-acetyl-2-naphthol (Fries, *Ber.*, 1921, **54**, 709) (5 g.) and ethyl formate (10 g.) was gradually added with vigorous shaking, and the whole left over-night. The solid yellow mass was then dissolved in ice-cold water and extracted with ether, and the aqueous layer separated and acidified with dilute sulphuric acid. The pale yellow oil obtained was extracted and dried (magnesium sulphate) in ether, recovered, and refluxed with absolute alcohol (50 c.c.) and concentrated sulphuric acid (10 c.c.) during 3 hours. The sticky product obtained when the solution was poured into water was washed with dilute aqueous caustic soda, then with water, and dried in a desiccator. Two crystallisations from light petroleum (b. p. 60—80°) gave 1 : 4-βα-*naphthapyrone* in stout, pale yellow needles, m. p. 103° (Found: C, 79·3; H, 4·5. $C_{13}H_8O_2$ requires C, 79·6; H, 4·1%). The substance is readily soluble in alcohol, benzene, and glacial acetic acid, sparingly soluble in cold light petroleum, and moderately easily soluble in the hot solvent. The colourless solution in boiling glacial acetic acid is unchanged in colour but develops a blue fluorescence on the addition of a drop of sulphuric acid. The colourless solution in sulphuric acid exhibits a blue fluorescence. The solution in absolute alcohol becomes turbid yellow on treatment with sodium amalgam and gives with magnesium and hydrochloric acid a brownish-orange colour.

2-*Acetyl*-3-*methyl*-1 : 4-βα-*naphthapyrone* (I) *and* 3-*Methyl*-βα-*naphthapyrone* (II; R = Me).—1-Acetyl-2-naphthol (2 g.), acetic anhydride (7 g.), and sodium acetate (4 g.) were heated together for

5 hours at 170°. The mixture was cooled, water (100 c.c.) added, and the whole boiled for 2 hours and again cooled. The solid that separated (1·3 g.) crystallised from alcohol in pale yellow needles, m. p. 157°, identified as (I) (Schneider and Kunau, *loc. cit.*, give m. p. 157—158°; Wittig, *Annalen*, 1925, **446**, 155, gives m. p. 156—157°) (Found : C, 75·8; H, 5·2. Calc. for $C_{16}H_{12}O_3$: C, 76·2; H, 4·7%). Treatment of the substance with alcoholic ammonia (Schneider and Kunau, *loc. cit.*) gave 3-methyl-1 : 4-βα-naphthapyrone, m. p. 168° (Wittig gives m. p. 164°) (Found : C, 79·7; H, 5·0. Calc. for $C_{14}H_{10}O_2$: C, 80·0; H, 4·7%). The colourless solution in sulphuric acid has a blue fluorescence.

βα-*Naphthaflavone* (II; R = Ph).—An intimate mixture of 1-acetyl-2-naphthol (2 g.), benzoic anhydride (20 g.), and sodium benzoate (4 g.) was heated for 4 hours at 180—185°. A solution of the product in boiling alcohol (80 c.c.) was heated with aqueous caustic soda (10 g. in 20 c.c. of water) for 15 minutes on the water-bath and poured into a large volume of water. The precipitate obtained crystallised from alcohol (charcoal) in colourless needles (0·9 g.), m. p. 163° (Tambor, Plattner, and Zuch, *loc. cit.*, give 164°) (Found : C, 83·6; H, 4·6. Calc. for $C_{19}H_{12}O_2$: C, 83·8; H, 4·3%). The colourless solution in sulphuric acid shows a blue fluorescence.

4′-*Methoxy*-βα-*naphthaflavone* (II; R = $C_6H_4{\cdot}OMe$).—1-Acetyl-2-naphthol (2 g.), anisic anhydride (15 g.), and sodium anisate (5 g.) were heated together for 4 hours at 185—190°. After the product had been boiled with 10% sodium carbonate solution (100 c.c.) during 2 hours and cooled, the undissolved residue was extracted with light petroleum, which left a substance (0·08 g.), m. p. 170°; this gave a yellow non-fluorescent solution in sulphuric acid and was not identified. The petroleum extract on cooling deposited the *methoxynaphthaflavone*, which crystallised from alcohol in clusters of long needles (1·2 g.), m. p. 165° (Found : C, 79·1; H, 4·9. $C_{20}H_{14}O_3$ requires C, 79·5; H, 4·6%). The crystals are coloured greenish-yellow by concentrated sulphuric acid, and the very pale yellow solution in the acid exhibits a brilliant sky-blue fluorescence.

3′ : 4′ : 5′-*Trimethoxy*-βα-*naphthaflavone* [II; R = $C_6H_2(OMe)_3$].—The chromone synthesis was carried out as in previous cases with 1-acetyl-2-naphthol (2 g.), trimethylgallic anhydride (12 g.), and sodium trimethylgallate (5 g.). Hydrolysis of the excess of anhydride was effected by means of 5% sodium carbonate solution (200 c.c.); the undissolved material crystallised from alcohol (charcoal) in long silky needles (0·4 g.), m. p. 159° (Found : C, 72·7; H, 5·2. $C_{22}H_{18}O_5$ requires C, 72·9; H, 5·0%). The pale yellow solution in sulphuric acid has a weak green fluorescence.

4′-*Methoxy*-βα-*naphthaflavanone* (III; R = $C_6H_4{\cdot}OMe$).—A mixture of 1-acetyl-2-naphthol (1·4 g.), anisaldehyde (1 g.), and alcohol (20 c.c.) was after addition of 50% caustic soda solution (2 g.) boiled for an hour on the water-bath, and the red liquid then poured on ice and acidified with acetic acid. The resinous mass was washed and repeatedly crystallised from alcohol, giving colourless, slender, rectangular prisms (1·2 g.), m. p. 143° (Found: C, 78·6; H, 5·5. $C_{20}H_{16}O_3$ requires C, 78·9; H, 5·3%). The crystals are coloured bright orange by contact with sulphuric acid, and the yellow solution in the acid has a weak blue fluorescence. The alcoholic solution gives no coloration with ferric chloride, and when heated with acetic anhydride and a drop of pyridine and poured into water the substance is recovered unchanged.

A solution of the flavanone (1 g.) in dry benzene (10 c.c.) was boiled for 10 minutes with phosphorus pentachloride (2·5 g.), cooled, and filtered. The solid, washed with a little dry benzene and crystallised twice from alcohol, gave 4′-methoxy-βα-naphthaflavone, m. p. 165°.

4′-Hydroxy-βα-naphthaflavone (II; R = $C_6H_4{\cdot}OH$).—A solution of the 4′-methoxynaphthaflavone (0·5 g.) in glacial acetic acid (10 c.c.) and acetic anhydride (5 c.c.) was boiled with hydriodic acid (*d* 1·7; 10 c.c.) for an hour, cooled, and poured into sodium bisulphite solution. The pale brown precipitate crystallised from alcohol in lemon-yellow rhombic plates, m. p. 283—285° (Found: C, 78·9; H, 4·4. $C_{19}H_{12}O_3$ requires C, 79·2; H, 4·2%). The *hydroxynaphthaflavone* dissolves in sulphuric acid with a pale yellow colour and a bright, pure blue fluorescence and in aqueous caustic soda with a greenish-yellow colour. The alcoholic solution gives no coloration with ferric chloride, a yellow colour with potassium acetate, and no precipitate with lead acetate or barium chloride solution. The colourless solution in boiling glacial acetic acid turns bright greenish-yellow on the addition of a drop of sulphuric acid. The solution in absolute alcohol gives a bright orange coloration with magnesium and hydrochloric acid; and with sodium amalgam turns greenish-yellow.

3′ : 4′-Dimethoxy-βα-naphthaflavanone [III; R = $C_6H_3(OMe)_2$].—A mixture of 1-acetyl-2-naphthol (2·3 g.), veratraldehyde (2 g.), alcohol (40 c.c.), and 50% caustic soda solution (4 g.) was treated in the same way as the similar mixture containing anisaldehyde. After three crystallisations from alcohol, the *product* was obtained in colourless rhombohedral plates (2·5 g.), m. p. 157° (Found: C, 75·1; H, 5·7. $C_{21}H_{18}O_4$ requires C, 75·4; H, 5·4%). The yellow solution in sulphuric acid has a scarcely perceptible green fluorescence. The other properties are similar to those of 4′-methoxy-βα-naphthaflavanone.

The condensation was repeated, 1-acetyl-2-naphthol (2·1 g.) and veratraldehyde (1·8 g.) being added to an ice-cold solution of sodium (0·5 g.) in absolute alcohol (30 c.c.) and left over-night. The red solid which had separated was removed; the filtrate was poured on ice and acidified, and the precipitate collected. Both substances, on crystallisation, gave the flavanone.

3′ : 4′-*Dimethoxy*-βα-*naphthaflavone* [II; R = $C_6H_3(OMe)_2$], obtained from the flavanone (2 g.) by the phosphorus pentachloride method described above, crystallised from alcohol in colourless feathery needles (0·2 g.), m. p. 168° (Found: C, 75·6; H, 5·2. $C_{21}H_{16}O_4$ requires C, 75·9; H, 4·8%). The yellow solution in sulphuric acid is non-fluorescent. The colourless alcoholic solution develops a pink colour after a few days.

The benzene filtrate, on addition of alcohol and concentration on the water-bath, gave unchanged flavanone (1 g.).

3′ : 4′-*Dihydroxy*-βα-*naphthaflavone*, obtained by the demethylation method previously described, crystallised from absolute alcohol, containing a few drops of glacial acetic acid, in pale yellow flakes, m. p. 302—304° (Found: C, 74·8; H, 4·3. $C_{19}H_{12}O_4$ requires C, 75·0; H, 3·9%). The very pale yellow solution in sulphuric acid exhibits a bluish-green fluorescence. The almost colourless solution in boiling glacial acetic acid turns bright yellow on the addition of a drop of sulphuric acid, but there is no separation of a mineral acid compound on cooling. The alcoholic solution gives a dark malachite-green coloration with ferric chloride; a greenish-yellow colour with potassium acetate; a greenish-yellow turbidity with lead acetate; and is unaffected by barium chloride solution. With magnesium and hydrochloric acid, the solution in absolute alcohol gives a bright orange colour, which becomes bright red on standing; and with sodium amalgam it turns orange-red.

3′ : 4′-*Methylenedioxy*-βα-*naphthaflavanone* (III; R=$C_6H_3{:}O_2CH_2$).—The reaction was carried out with 1-acetyl-2-naphthol (2·4 g.), piperonal (2 g.), alcohol (40 c.c.), and 50% aqueous caustic soda (4 g.). After repeated crystallisation from alcohol, the *substance* was obtained as pale yellow needles, m. p. 169°. The same substance was obtained by using sodium ethoxide in place of caustic soda (Found: C, 75·2; H, 4·6. $C_{20}H_{14}O_4$ requires C, 75·4; H, 4·4%).

3′ : 4′-*Methylenedioxy*-βα-*naphthaflavone* (II; R = $C_6H_3{:}O_2CH_2$), obtained from the flavanone by the phosphorus pentachloride method, crystallised from alcohol in colourless needles, m. p. 225—226° (Found: C, 75·6; H, 4·1. $C_{20}H_{12}O_4$ requires C, 75·9; H, 3·8%). The substance dissolves in sulphuric acid, giving a yellow solution with a blue fluorescence.

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[*Received, August 5th,* 1931.]