Rearrangement of 2 : 4-Xylyl Hydrogen Maleate.

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The rearrangement of 2 : 4-xylyl hydrogen maleate with aluminium chloride is discussed.

Baddeley, Makar, and Ivinson (*J.*, 1953, 3969) have shown that 2 : 4 : 1-xylenol and maleic anhydride in the presence of aluminium chloride yield β-(2-hydroxy-3 : 5-dimethylbenzoyl)acrylic acid (I; R = H). We had previously and unsuccessfully attempted to prepare this acid by Fries rearrangement (cf. Cocker, *J.*, 1946, 30; Cocker, Fateen, and Lipman, *J.*, 1951, 929) of 2 : 4-xylyl hydrogen maleate (II). In fact, when this ester was heated with aluminium chloride at 145°, the product was 4-hydroxy-5 : 7-dimethyl-3-oxoindane-1-carboxylic acid (III) identified by comparison with the product of the action of a mixture of aluminium chloride and sodium chloride on the aroylacrylic acid (I; R = H) (cf. Baddeley, Makar, and Ivinson, *loc. cit.*; personal communication from Dr. Baddeley). When however the ester (II) was heated with aluminium chloride in boiling tetrachloroethane (cf. Smith and Holmes, *J. Amer. Chem. Soc.*, 1951, **73**, 3847), a second isomeric acid was also obtained which unlike (III) gave no ferric reaction. The properties of this acid make it clear that it is 6 : 8-dimethyl-4-oxochroman-2-carboxylic acid (IV), and not the isomeric acid (V) (cf. Dann and Mylius, *Annalen*, 1954, **587**, 7). Thus the spectrum of the chroman acid (IV), as expected, is almost identical with that of the indane acid (III), whereas (V) would be expected to exhibit light absorption similar to the saturated esters of 2 : 4 : 1-xylenol.

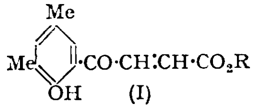
Substance	$\lambda_{max.}$ (in EtOH)	log ε
(III)	2170, 2620, 3350Å	4·31, 4·12, 3·76
(IV)	2170, 2590, 3420	4·53, 4·10, 3·75
2 : 4-Xylyl chloroacetate	2650, 2730	3·02, 2·98
2 : 4-Xylyl hydrogen succinate	2675, 2730	2·72, 2·69

Moreover the methyl ester of (IV) is produced when methyl β-(2-hydroxy-3 : 5-dimethylbenzoyl)acrylate (I; R = Me) is treated in the cold with tripropylamine in presence of five equivalents of diethyl malonate. The base-catalysed addition of the hydroxyl group of the phenol (I; R = Me) to the double bond is not unexpected, but eliminates structure (V) for the product. Diethyl malonate in excess is apparently essential for this reaction, the active anion $^-CH(CO_2Et)_2$ presumably being the catalyst (cf. Pepper, *Quart. Rev.*, 1954, **8**, 88). In absence of malonic ester the product is a dimer of (I; R = Me): the ferric reaction and spectrum of this product, both similar to those of the starting ester (I; R = Me), and its low reactivity towards hydrogen and hydrogen bromide in acetic acid, suggest that it is probably (VIII).

We have been unable to prepare 2 : 4-dimethylphenoxysuccinic acid (X) from which 6 : 8-dimethyl-4-oxochroman-2-carboxylic acid (IV) could have been produced. Reduction of 2 : 4-dimethylphenoxyfumaric acid (VI) (Baddeley, Makar, and Ivinson, *loc. cit.*) was unsuccessful by catalytic methods, whilst sodium amalgam gave mainly 2 : 4 : 1-xylenol. The diethyl ester of (VI) was also unchanged by hydrogen in presence of palladised charcoal, whilst in presence of platinic oxide the aromatic ring suffered reduction.

Oxidation of α-2 : 4-dimethylphenoxy-γ-butyrolactone (VII; R = R′ = Me), obtained from 2 : 4 : 1-xylenol and α-bromo-γ-butyrolactone, with chromium trioxide (cf. Julia, *Bull. Soc. chim.*, 1954, 471) gave an intractable gum, and with permanganate gave a product which had properties consistent with its formulation as (IX; R = Me, R′ = CO_2H, or *vice versa*). When heated above its melting point, or with sulphuric acid, the oxidation product gave a lactone (VII; R = Me, R′ = CO_2H, or *vice versa*).

Two forms of β-(2-hydroxy-3 : 5-dimethylbenzoyl)acrylic acid have been encountered (see Experimental section), namely, a yellow form, m. p. 149—153°, and a red form, m. p. 134—136°, into which the yellow form changed on standing under alcohol. Both gave the same hydrogen bromide adduct. The red form exhibited light absorption which characterised it as a mixture, probably of *cis*- and *trans*-forms, whilst the yellow, less stable form is probably the *cis*-form (cf. Iskrié, *Arhiv. Kem.*, 1954, **26**, 109; Rice, *J. Amer. Chem. Soc.*, 1923, **45**, 223).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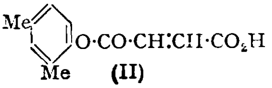
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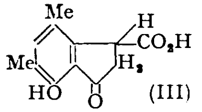
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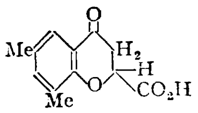
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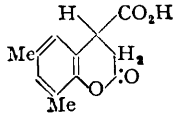
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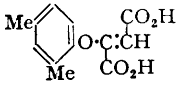
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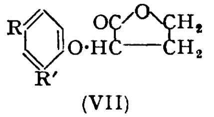
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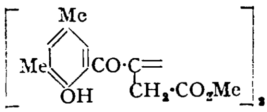
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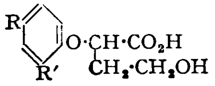
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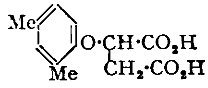
(X)

EXPERIMENTAL

Light-absorption measurements were performed in alcohol.

2 : 4-*Xylyl Hydrogen Maleate* (II).—2 : 4 : 1-Xylenol (5 g.), suspended in water (40 c.c.) containing sodium carbonate (2·17 g.), was stirred vigorously whilst powdered maleic anhydride (4·02 g.) was slowly added. When addition was complete, the solution was acidified, and the liberated yellow oil was extracted with benzene, from which the ester was leached with several portions of sodium carbonate solution. The combined extracts were slowly added to a well-stirred mixture of crushed ice and hydrochloric acid, and the precipitated *ester* (3·2 g.; m. p. 40—45°) crystallised from light petroleum as needles, m. p. 81·5—83° (Found: C, 66·5; H, 6·1. $C_{12}H_{12}O_4$ requires C, 65·5; H, 5·5%). It readily dissociated on storage and good analyses could not be obtained. Reduction in methyl alcohol over palladised charcoal gave 2 : 4-xylyl hydrogen succinate (Cocker, Fateen, and Lipman, *J.*, 1951, 929).

2 : 4-*Xylyl Hydrogen Fumarate.*—Bromosuccinic anhydride (22 g.) was heated at 145° for 4 hr. with 2 : 4 : 1-xylenol (12 g.). The mixture was then rapidly chilled to 0° and extracted with sodium carbonate solution, and the extract washed with ether. Acidification of the alkaline extract at 0° gave an oil, which on extraction with benzene gave a solid (1·5 g.; m. p. 93—97°) and a gum (8 g.). Two crystallisations of the solid from benzene gave the required *ester* as needles, m. p. 97—98° (Found: C, 65·7; H, 5·5. $C_{12}H_{12}O_4$ requires C, 65·5; H, 5·5%). Catalytic reduction, slower than in the case of its isomer, gave 2 : 4-xylyl hydrogen succinate, whilst attempted rearrangement with aluminium chloride gave fumaric acid. 2 : 4-Xylyl hydrogen maleate, in the ultra-violet range above 2150 Å, showed only a small inflexion at 2620 Å (log ε 3·07), whilst its *trans*-isomer showed a more pronounced inflexion, or maximum, at 2650 Å (log ε 3·22). These figures correspond closely to those quoted by Ley and Wingchen (*Ber.*, 1934, **67**, 501) for maleic and fumaric acid respectively.

Rearrangement of 2 : 4-*Xylyl Hydrogen Maleate.* 4-*Hydroxy*-5 : 7-*dimethyl*-3-*oxoindane*-1-*carboxylic Acid* (III).—The ester (2 g.) was powdered with aluminium chloride (6 g.), and the mixture was heated at 140—150° for 40 min. and added to ice and hydrochloric acid. The gum so produced was rubbed with benzene–light petroleum, giving a solid (0·2 g.; m. p. 130—150°) which after several crystallisations from benzene followed by dilute methyl alcohol gave the *acid* (III) as buff prisms, m. p. 170—171°, which gave an intense blue ferric reaction, $\lambda_{max.}$ 2170, 2650, 3350 Å (log ε 4·31, 4·12, and 3·76 respectively) (Found: C, 66·1; H, 5·6. $C_{12}H_{12}O_4$ requires C, 65·5; H, 5·5%). Its *semicarbazone* consisted of pale yellow needles (from dilute acetic acid), m. p. 294° (decomp.) (Found: C, 56·2; H. 5·5. $C_{13}H_{15}O_4N_3$ requires C, 56·3; H, 5·4%). Its *carbanilate* had m. p. 252—254° (decomp.) (Found: C, 72·3; H, 5·8. $C_{25}H_{22}O_4N_2$ requires C, 72·5; H, 5·3%). Its *methyl ester*, prepared from the acid and methanolic hydrogen chloride, consisted of needles (from dilute methyl alcohol), m. p. 63—64° (Found: C, 67·0; H, 6·0. $C_{13}H_{14}O_4$ requires C, 66·7; H, 5·9%). Reduction of the acid by the Clemmensen method gave 4-*hydroxy*-5 : 7-*dimethylindane*-1-*carboxylic acid* as buff prisms (from benzene)

m. p. 180—181° (Found : C, 70·6; H, 6·9; equiv., 192. $C_{12}H_{14}O_3$ requires C, 69·9; H, 6·8%; equiv., 206).

6 : 8-*Dimethyl*-4-*oxochroman*-2-*carboxylic Acid* (IV).—A boiling solution of 2 : 4-xylyl hydrogen maleate (3 g.) in tetrachloroethane (40 c.c.) was treated during 30 min. with finely powdered aluminium chloride (22·8 g.). Further solvent (40 c.c.) was then added and the mixture was boiled for 40 min., cooled, poured into ice and hydrochloric acid, and set aside overnight. The aqueous layer was extracted with ether, and the combined organic extracts were distilled in steam, giving recovered xylenol (11 g.), and a gum (15 g.) from which the aqueous liquor was decanted. The gum on extraction with sodium carbonate, filtration of the extract, and acidification gave the acid (III) (1·1 g.) obtained by the first method. The aqueous liquors, on cooling, deposited a solid (1·5 g.), m. p. 155—170°, which on crystallisation from dilute alcohol afforded 6 : 8-*dimethyl*-4-*oxochroman*-2-*carboxylic acid* (IV) as colourless needles, m. p. 170°, depressed to 140—150° by the acid (III). It failed to give a ferric reaction (Found : C, 66·2; H, 5·4. $C_{12}H_{12}O_4$ requires C, 65·5; H, 5·5%).

β-(2-*Hydroxy*-3 : 5-*dimethylbenzoyl*)*acrylic acid* was prepared by the method of Baddeley *et al.* (*loc. cit.*). After decomposition of the aluminium chloride complex with ice and hydrochloric acid, the solvent was removed by distillation in steam, giving the acrylic acid (43%) as red needles, m p. 134—136° (Dr. Baddeley; personal communication), $\lambda_{max.}$ 2250, 2640, 2740, 2920, 3860 Å (log ε 4·22, 4·01, 4·04, 4·05, and 3·51 respectively). Its *methyl ester*, prepared by methyl alcohol and sulphuric acid, consisted of bronze needles (from methyl alcohol), m. p. 97—98°, $\lambda_{max.}$ 2170, 2590, 3410 Å (log ε 4·41, 4·02, and 3·67 respectively) (Found : C, 66·6; H, 5·9. $C_{13}H_{14}O_4$ requires C, 66·7; H, 6·0%). When the steam-distillation was protracted, a bronze-coloured viscous mass was obtained.

When the product after decomposition of the aluminium chloride complex was shaken for a few minutes, the gum rapidly solidified, giving a yellow *form* of the acrylic acid (73% yield) as flat needles (from dilute methyl alcohol), m. p. 149—153°, $\lambda_{max.}$ 2650, 3530 Å (log ε 3·98, and 3·53 respectively) (Found : C, 64·9; H, 5·6. $C_{12}H_{12}O_4$ requires C, 65·5; H, 5·5%). Addition of hydrogen bromide in acetic acid to either the yellow or the red form gave α-*bromo*-β-(2-*hydroxy*-3 : 5-*dimethylbenzoyl*)*propionic acid* (cf. Clemo, Haworth, and Walton, *J.*, 1929, 2368; Cocker and Lipman, *J.*, 1947, 533; Cocker, Lipman, and Whyte, *J.*, 1950, 1519) as yellow plates (from benzene), m. p. 147—148° (decomp.) $\lambda_{max.}$ 2170, 2600, 3490 Å (log ε 4·26, 4·02, and 3·67 respectively) (Found : C, 47·8; H, 4·3. $C_{12}H_{13}O_4Br$ requires C, 47·8; H, 4·3%).

Experiments using Tripropylamine and (I).—(*a*) Methyl β-(2-hydroxy-3 : 5-dimethylbenzoyl)-acrylate (2·3 g.) was dissolved in absolute alcohol (50 c.c.) containing diethyl malonate (8 g.), and tripropylamine (0·4 c.c.) was added. The solution was kept at 0° overnight, and then cooled to −10°; a solid (1·2 g.) was deposited. It was collected and crystallised from alcohol, to give *methyl* 6 : 8-*dimethyl*-4-*oxochroman*-2-*carboxylate* as needles, m. p. 98—100°, $\lambda_{max.}$ 2170, 2590, 3410 Å (log ε 4·45, 4·05, and 3·69 respectively) (Found : C, 66·8; H, 6·3. $C_{13}H_{14}O_4$ requires C, 66·7; H, 6·0%). The corresponding acid, obtained when the ester was refluxed with a mixture of concentrated hydrochloric acid and acetic acid, gave m. p. 168—170°, undepressed by the oxochroman obtained in the Fries rearrangement described above.

(*b*) When the acrylic ester (1·1 g.) in alcohol (12 c.c.) and tripropylamine (0·2 c.c.), but without malonic ester, were used, crystallisation took place in 30 min. but the mixture was set aside for 2 days. The product [?*methyl* 3 : 4-*di*-(2-*hydroxy*-3 : 5-*dimethylbenzoyl*)*hex*-3-*enedioate* (VIII)] (0·4 g.) crystallised from alcohol as yellow needles, m. p. 143—144°, $\lambda_{max.}$ 2180, 2610, and 3440 Å (log ε 4·72, 4·42, and 3·94 respectively) [Found : C, 66·6; H, 6·3; active H, 0·48%; *M* (Rast), 405. $C_{26}H_{28}O_8$ requires C, 66·7; H, 6·0; active H, 0·43%; *M*, 468]. When the acrylic ester (2·3 g.) in alcohol (24 c.c.) was treated with malonic ester (2 g.) and tripropylamine (0·4 c.c.), the yellow dimer (VIII) (1·1 g.) and the oxochroman ester (0·2 g.) were both produced.

Diethyl 2 : 4-*Dimethylphenoxyfumarate*.—This *ester* was obtained by the method of Baddeley *et al.* (*loc. cit.*) as a yellow liquid, b. p. 180°/8 mm. (Found : C, 65·75; H, 7·0. $C_{16}H_{20}O_5$ requires C, 65·8; H, 6·8%). The corresponding *acid* (VI) consisted of needles, m. p. 216° (from dilute methyl alcohol) (Found : C, 61·2; H, 5·3%; equiv., 118. $C_{12}H_{12}O_5$ requires C, 61·0; H, 5·1%; equiv., 118). Its *amide* (needles from alcohol) had m. p. 226° (Found : C, 61·4; H, 5·9. $C_{12}H_{14}O_3N_2$ requires C, 61·5; H, 6·0%).

Reduction of the ester over Adams's catalyst gave a liquid, b. p. 220°/43 mm., with a strong terpene-like odour, which on hydrolysis gave 2 : 4-*dimethyl*cyclo*hexyloxysuccinic acid* as tablets, m. p. 156—157° (Found : C, 58·8; H, 8·1. $C_{12}H_{20}O_5$ requires C, 59·0; H, 8·2%).

α-2 : 4-*Dimethylphenoxy*-γ-*butyrolactone* (VII; R = R′ = Me).—α-Bromo-γ-butyrolactone and the sodium salt of 2 : 4 : 1-xylenol were condensed according to Julia's method (*loc. cit.*), giving (VII) (64%), b. p. 224—226°/6 mm., which solidified and was crystallised as colourless plates (from light petroleum), m. p. 62—63° (Found: C, 70·25; H, 6·9. $C_{12}H_{14}O_3$ requires C, 69·9; H, 6·8%).

Oxidation of the Lactone (VII; $R = R' = Me$).—The lactone (6·1 g.) was heated with potassium hydroxide (1·88 g.) in water (50 c.c.) for ½ hr. The solution, just alkaline to litmus, was cooled to 5° and sodium carbonate (1·06 g.) was added. Potassium permanganate (9·48 g.) in water (185 c.c.) was added dropwise with stirring during 20 min. at $\not> 10°$. Stirring was continued for a further 3 hr. and the mixture was then set aside for 2 days. Manganese dioxide was collected, and the filtrate was concentrated to half its original bulk and then acidified with 25% hydrochloric acid. The colourless oil obtained was extracted several times with ether and with chloroform, giving the unorientated acid (IX; $R = Me$; $R' = CO_2H$ or *vice versa*) (1·05 g.), m. p. 129—130°, which crystallised from benzene–alcohol as colourless rhombs, m. p. 135—136°, $\lambda_{max.}$ 2570 Å (log ε 4·18) (Found: C, 57·0; H, 5·3%; equiv., 131·5. Calc. for $C_{12}H_{14}O_6$: C, 56·7; H, 5·5%; equiv., 127). The corresponding butyrolactone (VII) was obtained as plates (from dilute alcohol), m. p. 170°, $\lambda_{max.}$ 2520 Å (log ε 4·12) (Found: C, 60·8; H, 5·2%; equiv., 116. Calc. for $C_{12}H_{12}O_5$: C, 61·0; H, 5·1%; equiv., 119).

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