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THE STRUCTURE OF CATALPALACTONE

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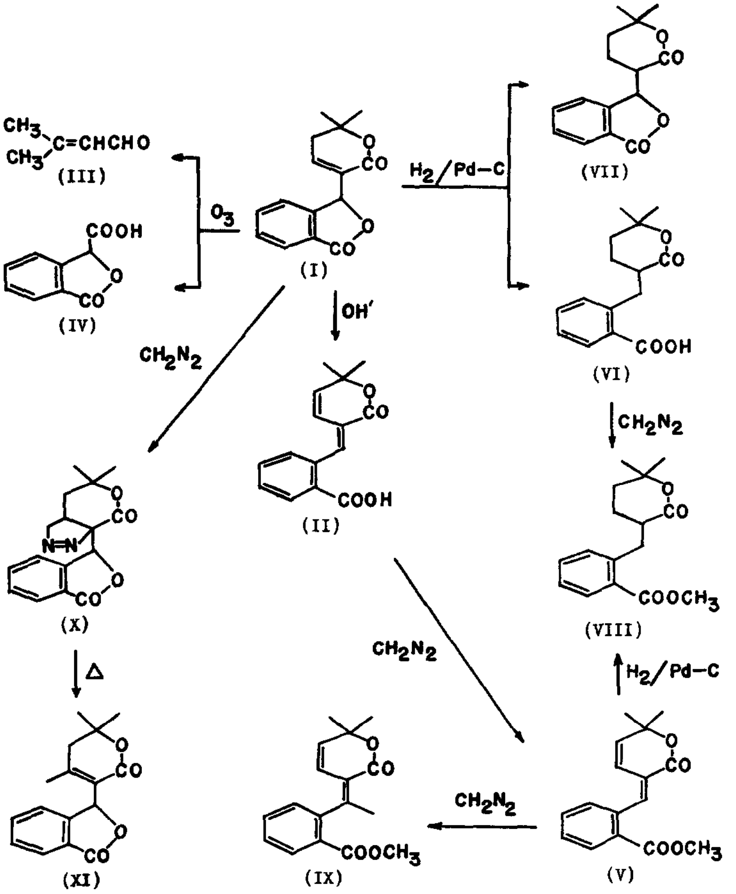
A new type of phthalide has been isolated from methanolic extract of the heartwood of Catalpa ovata G. Don. The compound, now termed catalpalactone (I), $C_{15}H_{14}O_4$, is dimorphous forming colourless crystals, m.p. 105-106° and 110-111°, and is optically inactive.(+) The spectra, λ_{max}^{EtOH} mμ(log ε): 275(3.21) and 282(3.20), $\nu_{max}^{CCl_4}$ 1782, 1715, 1600 and 1470 cm^{-1}, N.M.R., 8.66τ(s, 3H), 8.53τ(s, 3H), 7.4-7.6τ(m, 2H), 3.56-3.66τ(broad singlet, 1H), 3.23τ(t, J = 5 c.p.s., 1H) and 2.0-2.7τ(m, 4H) are indicative of two $H_3C-\overset{|}{\underset{|}{C}}-$ groups, a disubstituted phenyl, a methylene and a γ-lactone group. The infrared absorption at 1715 cm^{-1} is attributable to an α,β-unsaturated δ-lactone, for the solution obtained by the hydrolysis of (I) with barium hydroxide gave, by lyophilization, a residue which shows no carbonyl peak in the infrared spectrum besides new peaks which are assigned to carboxylate anion. On neutralization of the aqueous solution of the residue, (I) and an acid (II) of which the detail is shown later were obtained.

(+) The compound showed no optical rotation by the optical rotatory dispersion determination.



The potassium permanganate oxidation of (I) gave phthalic acid. The ozonolysis of (I) yielded β,β-dimethylacrolein (III) and phthalide carboxylic acid (IV) both in fairly high yield. The former was identified as the 2,4-dinitrophenylhydrazone, and the latter was confirmed by deriving to its methyl ester and phthalide. Accordingly, it is considered that (I) is a 3-substitute phthalide in which the substituent contains an α,β-unsaturated δ-lactone, and that β,β-dimethylacrolein was produced from the substituent.

The hydrolysis of (I) with sodium hydroxide followed by neutralization of the resulted solution yielded a monobasic acid (II), $C_{15}H_{14}O_4$, m.p. 138–139°; λ_{max}^{EtOH} 302mμ(log ε 4.11), ν_{max}^{KBr} 1715 and 1685 cm.$^{-1}$ N.M.R., AB quartet at 3.50τ and 4.09τ($J_{AB} = 10$ c.p.s., 2H) and 1.69–1.77τ(broad singlet, 1H). The ultraviolet spectrum indicates that a new conjugate system which includes a benzene ring was produced, and the infrared spectrum shows that the phthalide lactone of (I) was opened with elimination of -O- under the hydrolysis. The acid (II) afforded a methyl ester (V), $C_{16}H_{16}O_4$, m.p. 100.5–101° when treated with diazomethane for a few minutes.

The hydrogenation of (I) over palladium-charcoal catalyst produced an oily acid (VI) as the main product, and dihydrocatalpalactone (VII), $C_{15}H_{16}O_4$, m.p. 153–154°; λ_{max}^{EtOH} mμ(log ε): 228(4.00), 274(3.22) and 281(3.22) as a minor product. The acid, when treated with diazomethane, gave a methyl ester (VIII), $C_{16}H_{20}O_4$, m.p. 86–87°; λ_{max}^{EtOH} mμ(log): 231(3.93) and 280(3.12), ν_{max}^{KBr} 1710 cm.$^{-1}$ The N.M.R. spectrum lacks signal of vinyl proton. This ester was also obtained by catalytic hydrogenation of (V). It is therefore obvious that (VI) was produced by hydrogenolysis of the phthalide lactone and saturation of the double bond in (I)

The reactions of catalpalactone and the properties of its products are thus completely in accord with the assignment of structure (I). As for each of (II) and its derivatives, there are two possibilities: the structure shown by the scheme and its geometrical isomer.

An unusual reaction of diazomethane with the acid (II) has been found during the structure elucidation of (I). By prolonged treatments of (II) and (V) with ethereal solution of diazomethane at room temperature, an ester (IX), $C_{17}H_{18}O_4$, m.p. 121–122°; λ_{max}^{EtOH} 260mμ(log ε 3.94), ν_{max}^{KBr} 1725 and 1703 cm^{-1} was obtained. The N.M.R. spectrum of (IX) shows a singlet corresponding to three protons at 7.41τ and lacks the benzylic proton at 1.73–1.83τ of (V). The substitution of the benzylic hydrogen with the methyl group is also indicated by the comparison of the sharp peaks of AB quartet of the vinyl protons of (IX) with the finely split peaks of the corresponding signals in (II) and (V). This reaction is analogous to the reaction of diazomethane with coumalic acid[1] which has a conjugate system similar to those in (II) and (V).

The reaction of (I) with diazomethane afforded a pyrazoline derivative (X), $C_{16}H_{16}O_4N_2$, m.p. 163°(decomp.). The infrared band at 1560 cm^{-1} is indicative of a grouping N=N, and the ultraviolet absorption, λ_{max}^{EtOH} 324 mμ (log ε 2.26) is in the range of that of Δ^1-pyrazoline.[2] The pyrolysis of (X) gave (XI), $C_{16}H_{16}O_4$, m.p. 204-205°. The presence of an allylic methyl group in this compound is indicated by a broad singlet at 8.16-8.21 τ in the N.M.R. spectrum. The signal of the vinyl proton in (I) is missing.

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