On the Conformations of δ-Lactones

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IT has been deduced[1,2] from the results of X-ray analyses that the lactone group C–C–O–C is

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planar, and the inference has been drawn[3] that in a six-membered ring (δ-lactone) this constraint imposes a boat conformation.

In an attempt to explain the anomalously high carbonyl frequencies for the unbridged δ-lactone function in certain derivatives of the diterpenoid columbin,[4] we have been led further to consider the conformations of δ-lactones. This is made possible by the data available from several recent X-ray analyses of natural products containing this function. Calculations based on these data confirm in all cases the previous finding that the lactone group is planar, but establish that two conformations satisfy this condition in the case of δ-lactones: (*a*) the half-boat conformation (1) in which carbon atoms A and B of the lactone ring are displaced to the same side of the plane containing the lactone group and (*b*) the half-chair conformation (2) where carbon atoms A and B are on opposite sides of the plane. Moreover, although the number of examples at present available is small, it appears that conformation (2) in the crystal is associated with carbonyl absorption in the infrared (solution) within the range normally

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accepted[5] for δ-lactones [ν_{max} (solution) 1730—1750 cm.$^{-1}$], while conformation (1) corresponds to frequencies lying in a higher range [ν_{max} (solution) 1758—1765 cm.$^{-1}$] (see Table). It seems probable that the actual values found within

free to do so. The cases of simarolide,[6] glaucarubin,[7] and swietenine[8] provide examples within this class of δ-lactones fused to six-membered carbocyclic rings; unattached δ-lactones, such as δ-valerolactone [ν_{max} (CCl$_4$) 1748 cm.$^{-1}$] very

TABLE

| | Conformation | Displacement in Å from lactone plane | | $\nu_{C=O}$ cm.$^{-1}$† | Solvent | Derivative‡ used for i.r. |
		A	B			
Iridomyrmecin	(1)[9]	+1·15	+1·07	1758	CCl$_4$	(X)[13]
Isoiridomyrmecin ..	(1)[10]	+1·12	+1·14	1761	CCl$_4$	(IX)[13]
Isocolumbin	(1)[12]	+1·22	+1·25	1761	CCl$_4$	(X)[4a]
Limonin (A lactone)	(1)[11]	+0·77	+0·39	1758	CHCl$_3$*	(IX)[14]
		+1·11	+0·87			
Swietenine	(2)[8]	+0·33	−0·48	1732	CHCl$_3$*	(XVI)[15]
Simarolide	(2)[6]	+0·17	−0·54	1727	CHCl$_3$*	(I; R=R′=H)[16]
Glaucarubin	(2)[7]	+0·43	−0·30	1753§	CCl$_4$	(Ib)[17]

† I.r. spectra refer where appropriate to derivatives‡ in which the obscuring effect of other carbonyl functions has been removed. The compound used for i.r. measurement is indicated in the last column, the Roman numeral denoting its reference number, as given in the paper cited.
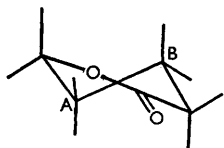
* Insoluble in CCl$_4$. Solvent shifts (CHCl$_3$ → CCl$_4$) for δ-lactones are +10—15 cm.$^{-1}$.[18]

§ α-Methoxy-δ-lactone.

these ranges may reflect at least partly the departure from the ideal geometries implied in (1) and (2). Such departures, imposed either by non-bonded interactions or distortion transmitted through bonds, are detectable within the significant limits of the X-ray data.
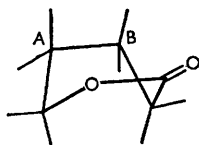
(1)   (2)

We suggest with the caution appropriate to the limited number of examples at present directly accessible through X-ray analyses, that δ-lactones normally adopt the half-chair conformation (2) if

probably also fall within this class, although X-ray data are not available. The boat conformation (1) probably arises only in response to special circumstances. Thus in iridomyrmecin,[9] isoiridomyrmecin,[10] and lactone A of limonin[11] the lactone ring is cis-fused at its β- and γ-carbon atoms to a five-membered ring. In isocolumbin,[4,12] the boat conformation removes the non-bonded interaction in the chair between the 1,3-diaxial methyl and furyl groups.

Bridged δ-lactones whose conformations are fixed in either the half-boat or half-chair, exhibit i.r. carbonyl frequencies in line with the above generalisation, so long as no additional strain factors are introduced. Thus the lactone of 4-hydroxycyclohexanecarboxylic acid (conformation 1) has ν_{max} (CCl$_4$) 1768 cm.$^{-1}$ and α-campholenolactone (conformation 2) has ν_{max} (CCl$_4$) 1744 cm.$^{-1}$

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