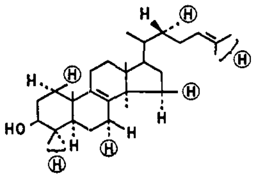
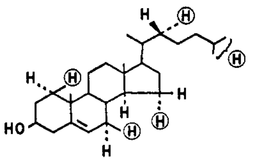
trione (V) and the tetraone (VII), with respect to the $12\beta,15\alpha$-diol (IV), indicates that the loss of tritium is associated entirely with the introduction of the 15α-hydroxyl group. Since, in microbial hydroxylations the hydroxyl group assumes the stereochemistry of the displaced hydrogen,[13] the loss in this step indicates the presence of a 15α-tritium in the progesterone and hence in the parent cholesterol. It follows that the saturation of the Δ^{14}-double bond occurs with the addition of hydrogens in the 14α and 15β configurations, *i.e.*, a *trans* addition, thereby paralleling the similar process in the saturation of the Δ^7 double bond.[14] The over-all result of events occurring at C-15 during the conversion of lanosterol to cholesterol is, therefore, the inversion of the proton originating from the *pro*-2*R*-hydrogen of mevalonic acid, from the 15β configuration in lanosterol[8] to the 15α orientation in cholesterol.

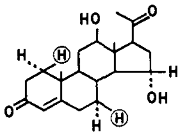
In summary, we have shown in this and an earlier communication,[8] that during the conversion of lanosterol (VIII) to cholesterol (I) in rat livers, of the three hydrogens derived from the *pro*-2*R*-hydrogen of mevalonic acid which occur in the steroid nucleus, only one (1β) retains its stereochemistry, while those at C-7 and C-15 undergo inversion. The biological significance of these results, together with our findings of stereochemical differences in the introduction of the Δ^7 double bond into C_{27} sterols in rats and in yeast[15] is at present under active investigation in our laboratories.



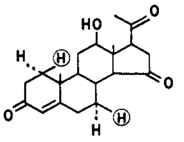
VIII



I



IV



V

Encircled hydrogens represent protons derived from the pro-2R-hydrogen of mevalonic acid and in the case of radioactive materials, are indicative of tritium atoms.

	$T/^{14}C$ ratio	Atomic ratio
Cholesterol	10.1	5.00:5
Pregnenolone	9.8	2.91:3
Progesterone (from pregnenolone)	9.1	2.70:3
Progesterone (from 20α-hydroxy-pregn-4-en-3-one)	9.8	2.91:3
$12\beta,15\alpha$-Dihydroxyprogesterone	6.2	1.84:3
12β-Hydroxypregn-4-ene-3,15,20-trione	6.6	1.96:3
Pregn-4-ene-3,12,15,20-tetraone	6.4	1.90:3

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Resonance Interactions in Substituted Ethylenes

Sir:

We wish to report that the integrated intensity (Table I) of the CC stretching mode near 1630 cm^{-1} of monosubstituted ethylenes[1] is closely proportional to the square of the $\sigma_R{}^0$ value of the substituent. Intensities for 18 compounds are plotted against $\sigma_R{}^0$ values[2] in Figure 1; a least-squares treatment of this data gives eq 1, with a correlation coefficient of 0.998.

$$A_{\mathrm{eth}} = 27{,}300(\sigma_R{}^0)^2 + 80 \qquad (1)$$

$$A_{\mathrm{mono}} = 17{,}600(\sigma_R{}^0)^2 + 100 \qquad (2)$$

This result is significant for a number of reasons. (a) Equation 1 is of the same form as eq 2 which correlates[3] the intensity of the ν_{16} ring-stretching bands of benzene in the 1600-cm^{-1} region, demonstrating the fundamental similarity of the interactions between the substituent and the carbon π bond(s) in the two systems. (b) Equation 2 has been used to calculate $\sigma_R{}^0$ values but is not accurate for $|\sigma_R{}^0| < 0.1$ because of the uncertainty due to the second term in the equation which is a correction factor needed because a combination band of C–H out-of-plane bending modes occurs in the same spectral region. A similar complication arises for eq 1 as the first overtone of the CH_2 in-plane rocking vibration interferes; however, the relative value of the correction term is only half the magnitude of that in eq 2. Therefore, relation 1 should be particularly suited to the measurement of small $\sigma_R{}^0$ values.[4] (c) Relation 2 has been shown[5] to hold in a modified form for di- and trisubstituted benzenes, and to afford considerable information on steric and electronic interactions between substituents; it may be expected that the intensities of poly-substituted ethylenes can be treated similarly.[4] (d) Relation 2 indicated that the intensity of ν_{16} in monosubstituted benzenes was largely due to the motion of the ring carbon atoms and suggested the possibility of molecular orbital calculations of absolute infrared intensities, which have succeeded;[6] similar calculations should be possible in the ethylene series.[4]

We wish to report preliminary extensions of this work along the lines just indicated. *trans*-1-Chloro-1-propene has $A = 268$; if eq 3 holds for *trans*-disubstituted ethylenes (based on analogy with *para*-disubstituted benzenes;[5a] as these compounds possess no CH_2 group, the overtone correction does not apply), then we deduce

$$A_{\mathrm{t-1,2}} = 27{,}300[\sigma_R{}^0(1) - \sigma_R{}^0(2)]^2 \qquad (3)$$

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(1) A. X. Wexler, *Spectrochim. Acta*, 21, 1725 (1965), has previously reported precise integrated intensities for the $\nu_{C=C}$ of some 1-alkenes; our values for 1-hexene (500) and styrene (339) are in good agreement with this (500; 400). We have used the values quoted for 1-pentene (470) and 4-methyl-1-pentene (460).

(2) The values for $\sigma_R{}^0$ used in the plot are those deduced from the ir of monosubstituted benzenes[3] except that for substituents CH_2Cl_2 and CH_2OH the ^{19}F values (R. W. Taft, E. Price, I. R. Fox, I. C. Lewis, K. K. Andersen, and G. T. Davis, *J. Amer. Chem. Soc.*, **85**, 3146 (1963)) are used because the ir values are uncertain as a result of the overtone correction. The substituent CH_2Br is not included in the plot as no ^{19}F value is available.

(3) R. T. C. Brownlee, R. E. J. Hutchinson, A. R. Katritzky, T. T. Tidwell, and R. D. Topsom, *ibid.*, 90, 1757 (1968).

(4) Work along these lines is in hand.

(5) (a) P. J. Q. English, A. R. Katritzky, T. T. Tidwell, and R. D. Topsom, *ibid.*, 90, 1767 (1968); (b) A. R. Katritzky, M. V. Sinnott, T. T. Tidwell, and R. D. Topsom, *ibid.*, 91, 628 (1969); (c) M. V. Sinnott, unpublished work.

(6) R. T. C. Brownlee, A. R. Katritzky, M. V. Sinnott, M. Szafran, L. Yakhontov, and R. D. Topsom, *Tetrahedron Letters*, 5773 (1968).

Table I. Infrared Spectra and $\sigma_R{}^0$ Values of Monosubstituted Ethylenes[a]

Substituent	$\nu_{C=C}$	A[b]	$\pm\sigma_R{}^{\circ}$[c]	$\sigma_R{}^{\circ}$[d]
Br	1597	1640	0.23	−0.16
I	1587	1209	0.22	−0.14
OEt	1638, 1652 1612	5149	0.44	...
OBu	1636, 1652 1612	5263	0.42[e]	...
OCOMe	1648	2115	0.23	−0.21
n-Pr	1641	470	0.11	...
sec-Bu	1641	460	0.11	...
t-Bu	1641	512	0.12	−0.17[f]
$CH(CH_2)_5$	1638	528	0.13	...
CH_2Ph	1638	359	0.12	−0.08
Ph	1630	339	0.10	−0.09
CH_2OH	1646	177	0.00	−0.07
CH_2Cl	1646 (sh), 1642	123	0.00	−0.03
CH_2Br	1646 (sh), 1638	87	0.00	...
$SiCl_3$	1598	301	0.09[e]	...
COOH	1637 1618	2304	0.29	+0.21
COOMe	1635 1622	733	0.15	...
COOEt	1638 1622	887	0.18	+0.19
CN	1650 1608	117	0.09	+0.21

[a] Frequencies and intensities refer to measurements in CCl_4 solution on a Perkin-Elmer 125 spectrometer. [b] Integrated intensity area in l. mole^{-1} cm^{-2}. [c] $\sigma_R{}^0$ derived from the ir intensity of monosubstituted benzene; taken from ref 3 unless otherwise stated. [d] $\sigma_R{}^0$ derived from the ^{19}F nmr spectra of substituted fluorobenzenes: taken from ref 9 unless otherwise stated. [e] Unpublished work by R. F. Pinzelli. [f] R. W. Taft and W. A. Sheppard, private communication.

that $|\sigma_R{}^0(Me) - \sigma_R{}^0(Cl)|$ is 0.10. We have $\sigma_R{}^0(Cl) = -0.23$ from ir measurements[3] which gives $\sigma_R{}^0(Me) = -0.13$, in fair agreement with the ir value of −0.10 and the ^{19}F value of −0.15 (see Taft, *et al.*, in ref 2).

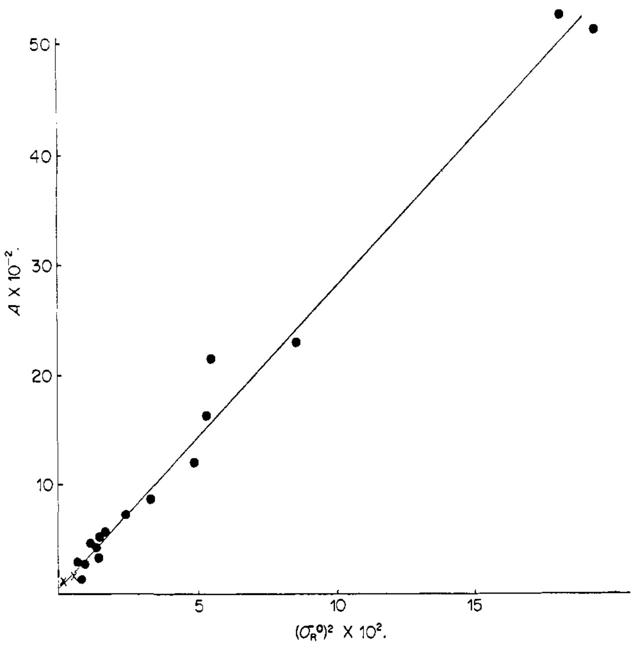

Figure 1. Integrated intensity of the infrared C=C stretching vibration for monosubstituted ethylenes plotted against the square of $\sigma_R{}^0$: ●, ir-derived $\sigma_R{}^0$ values; ×, ^{19}F-derived $\sigma_R{}^0$ values.

A normal coordinate analysis applicable to monosubstituted ethylenes has been carried out by Popov and Kagan[7] who quoted atomic displacements for the carbon and hydrogen atoms. We have, as before,[6] calculated by the CNDO2 method[8] the dipole moment at the equilibrium and stretched states of fluoroethylene and hence[6] found $\partial\mu/\partial Q$ as 39.6. The expected A value of fluoroethylene can be deduced from $\sigma_R{}^0(F) = 0.34$ as $A = 3235$ by reading off from Figure 1. This value of $A = 3235$ is equivalent to $\partial\mu/\partial Q = 67.8$ (*cf.* ref 6).

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(7) E. M. Popov and G. I. Kagan, *Opt. Spectry* (USSR), **12**, 102 (1962).

(8) J. A. Pople, D. P. Santry, and G. A. Segal, *J. Chem. Phys.*, **43**, S129, S136 (1965).

On the Solvation of Ions in Dipolar Aprotic Solvents. Chlorine-35 Nuclear Magnetic Resonance Studies of Chloride Ion in Mixed Solvents[1]

Sir:

Parker and his colleagues[2,3] have concluded that chloride ion activity increases by 8.0 ± 0.3 units on a *log-*

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(2) J. Miller and A. J. Parker, *J. Am. Chem. Soc.*, **83**, 117 (1961).

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