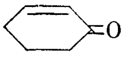
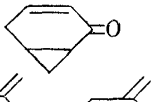
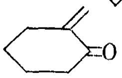
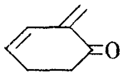
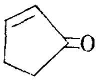
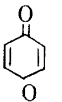
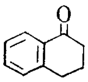
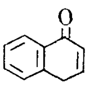
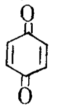
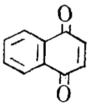
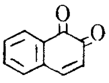
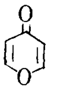
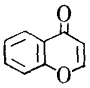
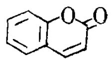
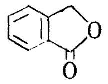
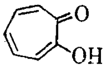
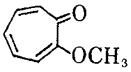
[Chem. Pharm. Bull. 14(7) 797~800 (1966)]

UDC 543.422.25 : 547.57.03

Solvent Shifts in the Nuclear Magnetic Resonance Spectra of Unsaturated Carbonyl Compounds[*1]

The nuclear magnetic resonance (NMR) signals of protons situated in the vicinity of carbonyl groups are known[1] to undergo solvent-induced shifts which can be of assistance in the assignment of structures. In a general survey to extend this application, we have found through measurement of over 70 compounds, that a hydrogen or a methyl, a methylene, or a methine group, attached to the α or β position of an α,β-unsaturated carbonyl system, or attached to the ortho position of an aromatic carbonyl compound

Table I. $\Delta\delta$ Values for Protons in Cyclic System

Type of ring system	s-trans					s-cis			
	hydrogens		CH_3, CH_2 and CH			hydrogens	CH_3, CH_2 and CH		
	α	β	α	β		β	β		others
		trans		trans	cis	cis	trans	cis	
	−0.07~0.07 (5)	0.22~0.49 (4)	−0.04 (1)	0.53 (1)					
	−0.13 (1)	0.42 (1)							
 						0.10 (1)	0.27 (1)	−0.11 (1)	
	0.41 (1)	0.88 (1)		0.45 (1)					
  	−0.12~−0.05 (2)			0.40 (1)	0.71 (1)	−0.33~−0.10 (3)			
  		0.43~0.67 (2)		0.42 (1)		0.01~0.07 (9)		0.06~0.13 (3)	γ : 0.52~0.60 (4)
 			0.67 (1)			−0.17 (1)			
	0.46 (1)	0.97 (1)							
					0.84 (1)	0.26 (1)			
	0.18~0.52 (2)	0.40~0.71 (4)	0.08~0.10 (2)						γ : 0.36~0.53 (3)
			−0.29 (1)	0.40 (1)					

[*1] Presented at Tohoku District Meeting, Chemical Society of Japan, at Yonezawa on June 21th, 1965.

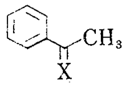
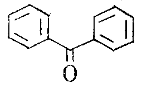
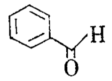
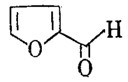
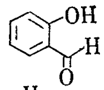
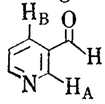
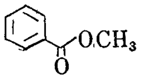
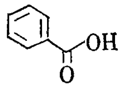
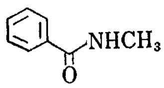
1) N.S. Bhacca, D.H. Williams : "Application of NMR Spectroscopy in Organic Chemistry, Illustrations from the Steroid Field," 159 (1964). Holden-Day, Inc., San Francisco.

or quinone system, undergoes, a solvent shift ($\Delta\delta=\delta_{CCl_4(\text{or } CDCl_3)}-\delta_{\text{benzene}}$)[*2] which can be related fairly regularly to the geometry of the unsaturated system, thus providing a means of deducing conformations or assigning signals to this type of compound.[*3]

Measurements were carried out with 5 mol. % solutions both in carbon tetrachloride (or deuteriochloroform) and in benzene. The results for a series of cyclic unsaturated carbonyl systems are listed in Table I which shows the $\Delta\delta$ for protons situated in the vicinity of carbonyl group.

From Table I, the following general tendency can be stated regardless of whether the substituent is a hydrogen or a methyl, methylene, or methine group : 1) In a *s-trans* system,[2] the substituent at the α-position always has a smaller $\Delta\delta$ (often negative) than that at the β-position; the largest shift observed so far for the α substituent of a simple 6-membered ring ketone is 0.07 p.p.m. whereas the smallest shift for the β substituent is 0.22 p.p.m. 2) This tendency still holds in 5-membered ring ketones although $\Delta\delta$ values for both positions increase considerably. 3) In a *s-cis* system,[2] the substituent at the β-*cis* position shows small $\Delta\delta$ values (0.10 p.p.m.) compared with their β-*trans* counterparts (0.27 p.p.m.). 4) Introduction of a double bond or cyclopropyl group at the α'-position

TABLE II. Solvent Shift in Aromatic Carbonyl Compounds

System		Hydrogen	Methyl		
		ortho	ortho	meta	para
 X=O		−0.12~0.18 (4)			0.35 (1)
X=NOH		0.03~0.07 (2)	0.15 (1)		
X=NOCH$_3$		−0.02 (1)			
		−0.12~0.05 (3)	0.00~0.01 (3)		0.15~0.26 (2)
	a[a]	−0.18~0.01 (5)			
	b[b]	0.19~0.73 (3)			
		−0.02 (1)			
		0.48			
	A	0.28			
	B	0.58			
		−0.17~−0.07 (3)	0.00 (1)	0.35 (1)	0.37 (1)
		−0.10~0.06 (4)	0.12 (1)	0.43 (1)	0.48 (1)
		0.06 (1)			

a) Those with no electron-attractive group.
b) Those with electron-attractive groups.

[*2] δ's measured in p.p.m. downfield from internal tetramethylsilane.

[*3] Although this survey is still in progress, the recent communication by Timmons (Chem. Commun., 576 (1965)) prompted us to publish the results obtained so far.

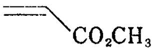
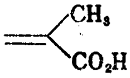
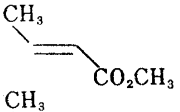
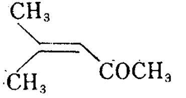
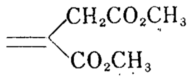
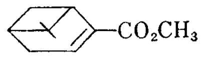
2) cf. E.L. Eliel : "Stereochemistry of Carbon Compounds," 331 (1962), McGraw Hill Book Co., New York.

has no effect on the above tendencies. 5) A substituent at the peri-position of a carbonyl group in the benzocyclohexenone system behaves in exactly the same way as in a simpler system. 6) Replacement of the methylene group with an oxygen (lactones, and pyrones) does not change the situation but the $\Delta\delta$ values increase. 7) $\Delta\delta$ values for a β-*cis* methylene in *s-trans* system are larger than normal. 8) The substituents in quinones rings behave as if they are at the β-position of a carbonyl group and show a large $\Delta\delta$ (0.43~0.67 p.p.m.). 9) Tropolones follow the same general tendency as in 1) above but to a lesser extent.

The general survey was extended to aromatic carbonyl compounds and the same tendency was observed for hydrogens and methyl groups at ortho positions as shown in Table II. Although experimental condition employed prevented the observation of $\Delta\delta$ for meta and para hydrogens, large $\Delta\delta$ values were observed for methyl groups at these positions. Table II indicates that not only ketones but also aldehydes, oximes, esters and amides, follow the same general tendency. A few exceptions having large $\Delta\delta$ values were noted amongst aromatic aldehydes. Those with a hydroxyl ortho to the aldehyde group, probably owe the large solvent shift to the existence of fixed geometry due to the strong hydrogen bonding. The large shift found in other aldehydes can be attributed to presence of strong electron-attracting groups in the benzene ring.[3]

Using this general rule, preferred conformations for open chain α,β-unsaturated carbonyl compounds can be assigned; a few examples are shown in Table III.

TABLE III. $\Delta\delta$ Values for Protons in Open Chain System

Compound	α		β-*cis*		β-*trans*		Preferred conformation
	H	CH_3	H	CH_3	H	CH_3	
	0.22		0.10		0.48		*s-cis*
		0.11	−0.06		0.28		〃
	0.02		0.10			0.52	*s-trans*
	0.23			0.02		0.37	*s-cis*
		0.28	0.03		0.43		〃
			−0.08				〃

These regularities suggest some applications of solvent shift of unsaturated compounds to constitutional or conformational problems. It was also noted that the chemical shifts of these vinylic hydrogens in various solvents follow a linear relationship with the dielectric constant of the solvent used. A detailed discussion of this phenomenon will be published separately.

The authors are grateful of the members of Organic Chemical Laboratories, Tohoku University, for a large supply of samples used in this study. Thanks are also due to Dr. N. S. Bhacca, Varian Associates, for his interest at early stage of the study.

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[3] cf. P. Diehl: J. Chem. Phys., **61**, 199 (1964).

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Received March 4, 1966

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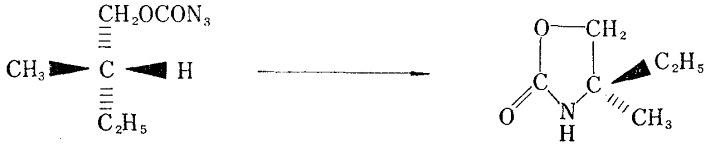
[Chem. Pharm. Bull. 14(7) 800~802 (1966)]

UDC 547.466.2.03 : 541.65

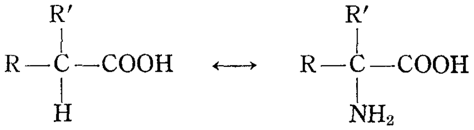
Determination of the Absolute Configuration of α-Methylphenylglycine by the Thermal Decomposition of the Azidoformate

In the previous communication,[1] the authors reported that the thermal decomposition of *S*(+)-2-methylbutyl azidoformate (*S*(+)-I) in diphenyl ether afforded *R*(+)-4-ethyl-4-methyl-2-oxazolidinone (*R*(+)-II) with nearly 100% retention of configuration. Accordingly, the results obtained suggested that this nitrene insertion reaction may be applicable to one of the methods for the determination of absolute configuration of a carboxylic acid (III) which has optically active tertiary C-H bond, or a α-alkyl-α-amino acid (IV) from the point of the reaction mechanism, if either one of the absolute configurations would be clear.



S(+)-I *R*(+)-II

Fig. 1.



$$\mathrm{R{-}\overset{R'}{\underset{H}{C}}{-}COOH} \longleftrightarrow \mathrm{R{-}\overset{R'}{\underset{NH_2}{C}}{-}COOH}$$

III IV

R, R'$\neq$H

Fig. 2.

On the absolute configuration of α-methylphenylglycine (2-amino-2-phenylpropionic acid) (IVa), which is one of the important α-alkyl-α-amino acids used frequently for the studies on the reaction mechanism,[2] Cram, *et al.*[2e] have deduced the absolute configuration of (+)-IVa to be *S*-series from the Freudenberg displacement rule and their studies on the carbanion chemistry. On the other hand, Maeda[2d] assumed that (+)-IVa is either *R*- or D-series without any convincing evidence. The discrepancy in these assignments cited above prompted us to undertake the examination of the correlation of the absolute configuration of IVa with that of hydratropic acid (2-phenylpropionic acid) (IIIa) whose absolute configuration has been already established,[3] using the thermal decomposition of the azidoformate prepared from IIIa.

The chemical scheme we employed is illustrated in Chart 1. A mixture of (+)-α-methylphenylglycine ((+)-IVa)(optical purity 82%[2a]) obtained from the resolution of

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[1] S. Yamada, S. Terashima, K. Achiwa: This Bulletin, **13**, 751 (1965).

[2] *a*) A. McKenzie, G.W. Clough: J. Chem. Soc., **101**, 390 (1912). *b*) A. McKenzie, J. Myles: Ber., **65**, 209 (1932). *c*) W.A. Bonner, J.A. Zderic: J. Am. Chem. Soc., **78**, 3218 (1956). *d*) G. Maeda: Nippon Kagaku Zasshi, **77**, 1011 (1956). *e*) D.J. Cram, L.K. Gaston, H. Jäger: J. Am. Chem. Soc., **83**, 2183 (1961). *f*) S. Mitsui, E. Sato: Nippon Kagaku Zasshi, **86**, 416 (1965).

[3] *a*) W.A. Bonner, J.A. Zderic: J. Am. Chem. Soc., **81**, 3336 (1959) and the ref. 15~22 therein. *b*) F.A.A. Elhafez, D.J. Cram: *Ibid.*, **74**, 5846 (1952) and the ref. 9 therein. *c*) W.A. Bonner, J.A. Zderic, G.A. Casalette: *Ibid.*, **74**, 5086 (1952) and ref. 6~11 therein.