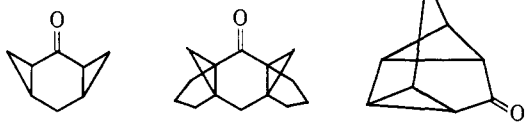
upfield from acetone and *ca.* 2.7 ppm upfield from acetaldehyde, while protonated acetophenone[2c] falls between acetone and benzophenone at δ 13.03. The OH chemical shift as a probe of electronic distribution also reflects nonclassical delocalization of positive charge. It is instructive to compare the O–H chemical shifts of protonated cyclopropyl ketones[6] with phenyl- and alkyl-substituted ketones (Table I). In each case the OH chemical shifts of the analogous protonated cyclopropyl and phenyl ketones are nearly equivalent,[7] both occurring at much higher field than the alkyl derivatives. Pronounced electron supply by cyclopropyl groups is further illustrated by the conjugate acids of other interesting dicyclopropyl ketones, *e.g.*, V, VI,[8a] and VII.[8b]

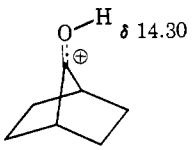


δ 11.77 (s) V

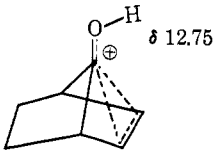
δ 10.98 (s) VI

δ 12.17 (s) VII

The present technique can be used effectively to illustrate electron delocalization in other nonclassical ions. Thus, it is instructive to compare the O–H resonance of protonated 7-norbornanone (VIII) at δ 14.30 with the OH resonance of protonated 7-norbornenone (IX) at δ 12.75.[9] The dramatic upfield shift of 1.55 ppm reflects significant delocalization of the π-olefinic electrons in IX. Another interesting bridged ion is X.[8c] In this species the OH chemical shift at δ 10.78, at 0.72-ppm higher field than in the case of the classical ion XI,[8d] reflects the extensive involvement of the cyclopropane ring in electron delocalization.[8c]

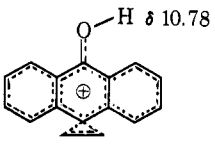


δ 14.30 VIII

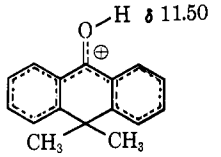


δ 12.75 IX

While our emphasis is on charge and electron-delocalization effects, we must note that the magnetic anisotropy of the protonated carbonyl group helps determine the actual values of the O–H chemical shifts. Deshielding effects due to magnetic anisotropy of the carbonyl group are decreased by protonation, and this explains why the chemical shift of the aldehydic proton in the protonated aldehydes is nearly the same as in the free aldehyde. The magnetic anisotropy effects are still large enough in the protonated aldehydes and ketones to contribute appreciable deshielding of the O–H proton. The magnetic anisotropic effect is decreased by charge delocalization, and thus electron delocalization and magnetic anisotropic effects are intertwined. In the case of protonated 7-norbornenone



δ 10.78 X



δ 11.50 XI

(IX), one should consider the magnetic anisotropic effect of the "olefinic group" on the O–H proton. Models suggest that this effect is quite small. Also, it is most likely deshielding and thus in the opposite direction from the observed substantial shielding of the O–H proton compared to protonated norbornanone (VIII).

(6) (a) T. J. Sekuur and P. Kranenburg, *Tetrahedron Letters*, 4769 (1966), report a series of protonated substituted phenyl cyclopropyl ketones but do not discuss the significance of the O–H chemical shift; (b) other authors have protonated cyclopropyl ketones in acidic media, but have reported only the C–H proton signals.

(7) From detailed consideration of conformations it is evident that the large upfield shifts of the O–H proton in protonated cyclopropyl carboxaldehyde and cyclopropyl ketones relative to alkyl analogs are not largely due to cyclopropyl ring-current effects.

(8) (a) L. Birladeanu, H. Hanafusa, and S. Winstein, *J. Am. Chem. Soc.*, **88**, 2315 (1966); (b) N. A. LeBel and R. N. Liesemer, *ibid.*, **87**, 4301 (1965); (c) L. Eberson and S. Winstein, *ibid.*, **87**, 3506 (1965); (d) ions X and XI examined in 5.5:1 FSO_3H–SbF_5.

(9) H. G. Richey and R. K. Lustgarten, *J. Am. Chem. Soc.*, **88**, 3136 (1966), report the C–H proton resonances for protonated 7-norbornenone in FSO_3H.

(10) National Institutes of Health Predoctoral Fellow, 1965–1967.

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Effect of Base Strength upon Orientation in Base-Promoted Elimination Reactions

Sir:

The evidence for the proposal[1] that the size of alkoxide bases significantly affects orientation in base-promoted eliminations is a series of experiments[1b] in which not one but three experimental conditions were changed between each comparative experiment within the series. In addition to a change in base size, the solvent and the strength of the base were changed. The authors recognized this ambiguity in their experiments but presented arguments, which have generally been accepted,[2] to discount these latter two changes as being contributory factors to the results obtained.

(1) (a) H. C. Brown and I. Moritani, *J. Am. Chem. Soc.*, **78**, 2203 (1956); (b) H. C. Brown, I. Moritani, and Y. Okamoto, *ibid.*, **78**, 2193 (1956); (c) H. C. Brown and I. Moritani, *ibid.*, **75**, 4112 (1953); (c) H. C. Brown and R. L. Klimisch, *ibid.*, **88**, 1425 (1966).

(2) (a) The following authors accept the steric proposal: J. D. Roberts and M. C. Caserio, "Basic Principles of Organic Chemistry," W. A. Benjamin, Inc., New York, N. Y., 1964, p 311; A. H. Corwin and M. M. Bursey, "Elements of Organic Chemistry," Addison-Wesley, Reading, Mass., 1966, p 518; E. S. Gould, "Mechanism and Structure in Organic Chemistry," Henry Holt, New York, N. Y., 1959, p 483. (b) The following author assigns an important role to the steric requirement of the base but points out that base strength may in part be responsible for the experimental trends: J. Hine, "Physical Organic Chemistry," 2nd ed, McGraw-Hill, Book Co., Inc., New York, N. Y., 1962, p 197. (c) The following author assigns an important role to the steric requirement of the base but also reports a system in which the strength of the base and the nature of the solvent are believed to affect relative rates: D. J. Cram in "Steric Effect in Organic Chemistry," M. S. Newman, Ed., John Wiley and Sons, Inc., New York, N. Y., 1956, pp 338–346. (d) The following authors' reports suggest an unwillingness to accept the steric requirement as a major factor: D. V. Banthorpe, "Reaction Mechanisms in Organic Chemistry," Vol. 2, E. D. Hughes, Ed., Elsevier Publishing Co., New York, N. Y., 1963, p 70; W. H. Saunders in "The Chemistry of Alkenes," S. Patai, Ed., Interscience Publishers, Inc., New York, N. Y., 1964, p 195.

Table I. Composition of Olefinic Products from the Elimination of 2-Butyl *p*-Toluenesulfonate at 55°: Effect of Solvent

Base	Solvent	% 1-*ene*	*trans*-2-ene/*cis*-2-ene
KOEt	EtOH	35[3a]	1.95
KOEt	DMSO	54[3a]	2.34
KOEt	*t*-BuOH	54[3c]	0.80
KOEt	DMF	52	2.60
KOEt	THF	59	1.65

We have previously reported experiments[3] in which the ratio of 1-ene to 2-ene changes with changes only in the solvent for the reaction. Summarized in Table I are some additional data which illustrate the dependence of orientation on the identity of the solvent for a particular substrate and base. Summarized in Table II are data which demonstrate that orientation of elimination is significantly affected by base strength alone.

The above, our previous stereochemical studies,[3a] and our more recent studies with *erythro*- and *threo*-3-deuterio-2-butyl *p*-toluenesulfonates[6] in both dimethyl sulfoxide and *t*-butyl alcohol using alkoxide bases suggest that these eliminations are mechanistically of the E2 type.

The data in Table II are completely consistent with a correlation between orientation and base strength. With the stronger bases, C–H stretching is more enhanced in the transition state; thus, hydrogen acidity becomes a more important factor in determining the relative rate of elimination into each branch.

We are aware of two previous reports[7,8] which contain evidence, from the comparison of bases of different strength in the same solvent, that orientation is more dependent upon base strength than size. However, each of these reports compares a base in which oxygen is the basic atom with a base in which sulfur is the basic atom. Since the rates of elimination are considerably greater for the sulfur bases, which are the thermodynamically weaker bases, the interpretation of these reports was not completely clear. It could be argued, for example, in one case[7] that the more reactive base would be expected to be less selective, as observed. However, our results suggest these reports are best explained by assuming that the stronger base thermodynamically (the oxide base in each case) more selectively removes the more acidic hydrogens.

Table II. Composition of Olefinic Products from the Elimination of 2-Butyl *p*-Toluenesulfonate at 55°: Effect of Base Identity

Base	pK_a of conjugate acid at 25°	Solvent	% 1-ene[a]	*trans*-2-ene/*cis*-2-ene
KO-*t*-Bu	19 ± 1[b]	DMSO	61[3a]	2.53
KOEt	15.9[c]	DMSO	54[3a]	2.34
KOC_6H_5	9.95[d]	DMSO	31 ± 2	1.96
KOC_6H_4-4-OCH_3	10.20[d]	DMSO	33 ± 3	1.97
KOC_6H_4-4-NO_2	7.14[d]	DMSO	16 ± 2	1.81
KOC_6H_4-2-NO_2	7.23[d]	DMSO	16 ± 2	1.85
KO-*t*-Bu	19 ± 1[b]	*t*-BuOH	64[3c]	0.58
KOEt	15.9[c]	*t*-BuOH	54[3c]	0.80
KOH	15.7	*t*-BuOH	50 ± 1	0.83
KOC_6H_5	9.95[d]	*t*-BuOH	34 ± 2	1.24

[a] The average of two to six experiments. The ± values give the range of results. [b] Estimated by W. K. McEwen, *J. Am. Chem. Soc.*, **58**, 1124 (1936). [c] F. A. Long and P. Ballinger, "Electrolytes," Pergamon Press, New York, N. Y., 1962, p 152. [d] H. C. Brown, D. H. McDaniel, and O. Häfliger in "Determination of Organic Structure by Physical Methods," E. A. Braude and F. C. Nachod, Ed., Academic Press Inc., New York, N. Y., 1955, p 567.

The reactions were carried out under conditions previously described.[3a] Sufficient products were collected within 20–30 min from the phenoxide eliminations, whereas the nitrophenoxide eliminations required 1.5–2 hr. Control experiments with 2-butyl tosylate in dimethyl sulfoxide at 55° produced only trace amounts of *trans*-2-butene and *cis*-2-butene, as determined by gas chromatography after 8 hr. A further control experiment with 2-butyl tosylate and potassium sulfate in dimethyl sulfoxide produced no observable butenes after 6 hr. On the basis of this, we concluded that solvolytic eliminations did not contribute to the products collected and analyzed. Recent studies[4] in methanol with thioethoxide (pK_a = 10.50[5] at 20°), which is a better nucleophile than phenoxides, have not provided support for the "merged" mechanism concept. In view of this and the solvent properties of both dimethyl sulfoxide and *t*-butyl alcohol and their effect upon base-promoted reactions, we feel that there is no reason to believe that products from the phenoxide eliminations were formed *via* a "merged elimination."

In view of the above data and considerations, it is now apparent that both base strength and solvent identity have important effects upon the orientation of elimination. That the size of oxide bases is an important factor is yet to be demonstrated. Further, it is our feeling that the above suggests that, in general, the steric requirements of oxide bases will be much less important than the above two factors.

Acknowledgments. Experimental assistance was provided by W. Dowd and H. R. Pinnick, Jr., and acknowledgment is made to the donors of the Petroleum Re-

(3) (a) D. H. Froemsdorf and M. E. McCain, *J. Am. Chem. Soc.*, **87**, 3983 (1965); (b) D. H. Froemsdorf, M. E. McCain, and W. W. Wilkison, *ibid.*, **87**, 3984 (1965); (c) D. H. Froemsdorf, W. Dowd, and K. E. Leimer, *ibid.*, **88**, 2345 (1966).

(4) J. F. Bunnett and E. Bacciochi, *J. Org. Chem.*, **32**, 11 (1967).

(5) J. P. Danehy and C. J. Noel, *J. Am. Chem. Soc.*, **82**, 2511 (1960).

(6) D. H. Froemsdorf, W. A. Gifford, and W. Dowd, Second Midwest Regional Meeting of the American Chemical Society, Lawrence, Kansas, Oct 27, 1966, Abstracts, p 40.

(7) (a) J. F. Bunnett, *Angew. Chem. Intern. Ed. Engl.*, **1**, 225 (1962); (b) J. F. Bunnett, G. T. Davis, and H. Tanida, *J. Am. Chem. Soc.*, **84**, 1606 (1962).

(8) W. H. Saunders, Jr., S. R. Fahrenholtz, E. A. Caress, J. P. Lowe, and M. Schreiber, *ibid.*, **87**, 3401 (1965).

search Fund, administered by the American Chemical Society, for support of this research.

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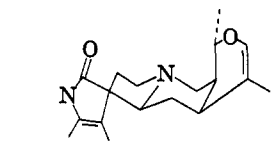
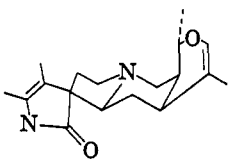
The Stereochemistry of the Pentacyclic Oxindole Alkaloids

Sir:

The assignment of configurations to the pentacyclic oxindole alkaloids has been one of the paramount problems remaining in alkaloid stereochemistry, and it is the purpose of this communication to describe the configurations of the oxindoles formosanine (uncarine-B), isoformosanine (uncarine-A), pteropodine, isopteropodine, rauniticine-*epiallo*-oxindole-B, rauniticine-*epiallo*-oxindole-A, rauniticine-*allo*-oxindole-B, rauniticine-*allo*-oxindole-A, rauvoxine, and rauvoxinine.[1] Additionally, all the other remaining pentacyclic oxindoles can now be assigned specific configurations by comparison with the bases that will presently be discussed. There are twelve stereochemical groups into which the oxindoles can be classified, and these are shown in the partial diagrams I–VI below.[2]


I-B, *allo*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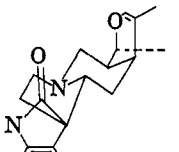
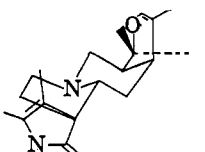

II-B, *epiallo*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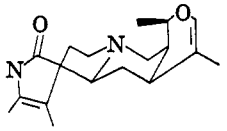
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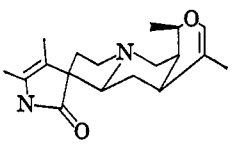
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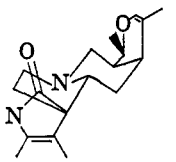
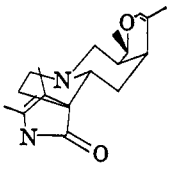
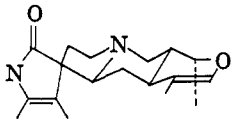
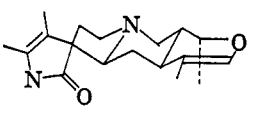

IV-B, *epiallo*


IV-A, *epiallo*


V-B, *normal*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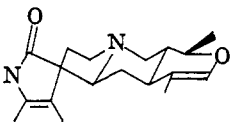
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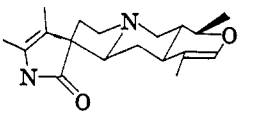
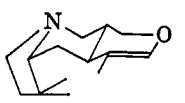
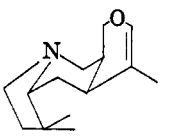

VI-A, *normal*


VII, *pseudo*


VIII, *epiallo*

Such arrangements as the *pseudo* expression VII need not be considered because of the serious steric interference between the oxindole moiety and the underbelly of ring D. This species would also show a very fast rate of N-methylation,[3] and experimentally no rapid rate was found. It follows that the *epiallo* configuration VIII is not an important one since it is even less favored than VII. The prior assignments of configurations I-B, V-B, and V-A to carapanaubine, mitraphylline, and isomitraphylline, respectively, are based on firm chemical and physical evidence and were reliable guideposts in our work.[1,4]

The pair of alkaloids represented by rauvoxine and rauvoxinine has been chemically related to carapanaubine,[5] and comparison of the chemical shifts of their C-19 methyl groups with that for carapanaubine (I-B) confirms that rauvoxine and rauvoxinine must be *epiallo* rather than *allo*. Rauvoxinine is more stable in acid solution than rauvoxine, so that the former must be represented by II-A and the latter by II-B. The basic nitrogen in II-A is less hindered than in II-B, and this is reflected in the higher rate of quaternization for rauvoxinine (see Table I).

Turning now to the *allo–epiallo* system with β-C-19 methyl groups, our starting point was the heteroyohimbine alkaloid rauniticine, of known *allo* β-C-19-methyl stereochemistry.[3] Conversion of this base to its oxindole derivatives[4] gave two major and two minor components which did not correspond to any of the naturally occurring bases we had on hand. The major components were named rauniticine-*epiallo*-oxindole-B and rauniticine-*epiallo*-oxindole-A. Since facile isomerization of the C-3 heteroyohimbine position can occur during oxindole formation, and because in acid solution rauniticine-*epiallo*-oxindole-A is favored over rauniticine-*epiallo*-oxindole-B, these two bases were assigned respectively expressions IV-A and IV-B. Structure IV-A bears a marked relationship to rauvox-

(1) For a recent review on the oxindole alkaloids see J. E. Saxton, *Alkaloids*, **8**, 59 (1965).
(2) Following convention the A notation indicates an α-oxindole carbonyl, and B a β-carbonyl.
(3) M. Shamma and J. M. Richey, *J. Am. Chem. Soc.*, **85**, 2507 (1963).
(4) N. Finch, C. W. Gemenden, I. H-C. Hsu, and W. I. Taylor, *J. Am. Chem. Soc.*, **85**, 1520 (1963).
(5) J-L. Pousset and J. Poisson, *Compt. Rend.*, **259**, 597 (1964).