C–X bond. The first term decreases along the series R–H, R-Cl, R-Br, R-I as expected on the basis of decreasing D(R-X). On the other hand, the second term seems to be negligible for X—H (no repulsion between p electron of a radical and a positive H), but it probably is considerable for X = halogen. This accounts for the reported facts. Moreover, presence of electron withdrawing groups should decrease this repulsion and increase, therefore, the reactivity. For example, although $D(CH_3\text{-}I)$ is approximately equal to $D(CF_3\text{-}I)$,[4] the reactivity of CF_3I is greatly larger than that of CH_3I, pointing to the change in the repulsion energy. The same is found when reactivities of $PhCH_2Br$ and CCl_3Br are compared, since again $D(PhCH_2\text{-}Br) \sim D(CCl_3\text{-}Br)$.[4] The effect of repulsion energy in determining the rate of halogen abstraction reactions seems therefore to be indisputable.

We wish to thank Dr. John Meyer for his help in counting the radioactive samples.

[4] A. H. Sehon and M. Szwarc, *Proc. Roy. Soc.* (*London*), **A209**, 110 (1951).

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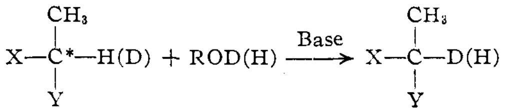
RECEIVED NOVEMBER 4, 1960

EFFECT OF STRUCTURE OF CARBANION-STABILIZING SUBSTITUENTS ON STEREOCHEMICAL COURSE OF HYDROGEN-DEUTERIUM EXCHANGE REACTIONS AT SATURATED CARBON

Sir:

Base-catalyzed hydrogen–deuterium exchange reactions at benzyl carbon of optically pure 2-phenylbutane and 1-phenylmethoxyethane previously were reported to occur with high retention of configuration in *tert*-butyl alcohol, and with complete racemization in dimethyl sulfoxide.[1]

We have now found that the steric course of the reaction varies widely with the structure of the carbanion-stabilizing group attached to the seat of substitution. The steric course in each case was established through comparison of the amount of racemization and exchange that had occurred after a short reaction period. The types of systems examined, the experimental conditions, and the results are recorded in Table I.



$$X\text{—}\overset{CH_3}{\underset{Y}{C^*}}\text{—}H(D) + ROD(H) \xrightarrow{\text{Base}} X\text{—}\overset{CH_3}{\underset{Y}{C}}\text{—}D(H)$$

Clearly 2-octyl phenyl sulfone undergoes electrophilic substitution[2] with high retention of configuration (85 to >97%) irrespective of the dissociating power of the solvent, the concentration of proton or deuteron donors, or the nature of the cation of the basic catalyst (runs 1–7). In contrast, the steric course of reaction of 2-phenylbutane and 1-phenylmethoxyethane depends markedly on these factors (runs 8, 9 and ref. 1). A third type of behavior is exhibited by 2-methyl-3-phenylpropionitrile, N,N-diethyl-2-phenylpropionamide and *tert*-butyl 2-phenylpropionate. In these systems, substitution occurs with complete racemization, irrespective of solvent character.

Although a detailed explanation requires further work, general patterns are visible in these results. In the first type of system exemplified by the sulfone, the carbanion formed as intermediate is probably asymmetric, and the stereospecificity of the reaction is not entirely dependent on maintaining an asymmetric solvent envelope. The carbanion might exist either as a d-orbital stabilized sp^3 hybrid with exchange occurring faster than inversion, or as a rehybridized but still asymmetric species in which carbon is "doubly bonded" to sulfur by p–d orbital overlap. In the latter case, formation and disposal of the carbanion might occur preferentially from the same side due to steric and (or) dipole–dipole interactions. Under such circumstances substitution could occur with retention of configuration.

TABLE I

	Starting material[a]					Base						
Run	X	Y	L[b]	Concn., M	Solvent	Type	Concn., M	Temp., °C.	Time, hr.	% Rac.	% Exch.[e]	Net steric course
1	$C_6H_5SO_2$	n-C_6H_{13}	H[c]	0.4	$(CH_3)_3COD$[d]	$(CH_3)_3COK$	0.396	25	0.05	4.5	62	93% Ret.
2	$C_6H_5SO_2$	n-C_6H_{13}	D[f]	.4	$(CH_3)_3COH$	$(CH_3)_3COK$	.224	25	0.70	8.0	96	92% Ret.
3	$C_6H_5SO_2$	n-C_6H_{13}	D[f]	.4	$(CH_3)_3COH$	$(CH_3)_4N^+OH^-$	.048	25	0.80	6	40	85% Ret.
4	$C_6H_5SO_2$	n-C_6H_{13}	D[f]	.4	$HOCH_2CH_2OH$	$HOCH_2CH_2OK$	.5	75	165	2.2	69	97% Ret.
5	$C_6H_5SO_2$	n-C_6H_{13}	H[c]	.4	$DOCH_2CH_2OD$[g]	$DOCH_2CH_2OK$	.5	100	2.25	4.5	53	91% Ret.
6	$C_6H_5SO_2$	n-C_6H_{13}	D[f]	.4	CH_3OH	CH_3OK	.5	100	7.0	48	100	High Ret.
7	$C_6H_5SO_2$	n-C_6H_{13}	D[f]	.4	$(CH_3)_2SO\text{–}CH_3OH$[h]	CH_3OK	.200	25	1.0	9.8	98	90% Ret.
8	C_6H_5	C_2H_5	D[i]	.19	$(HOCH_2CH_2O)_2H$	$(HOCH_2CH_2O)_2K$	.36	260	140	20	13	51% Inv.[j]
9	C_6H_5	OCH_3	D[k]	.12	$(HOCH_2CH_2O)_2H$	$(HOCH_2CH_2O)_2K$	.40	260	420	6.6	4	Rac. or inv.
10	$C_6H_5CH_2$	CN	H[l]	.14	$(CH_3)_3COD$[d]	$(CH_3)_3COK$	.013	25	1.3	20	19	100% Rac.
11	$C_6H_5CH_2$	CN	H[l]	.23	$DOCH_2CH_2OD$[g]	$DOCH_2CH_2ONa$	.14	84	19	52	52	100% Rac.
12	C_6H_3	$CON(C_2H_5)_2$	H[m]	.12	$(CH_3)_3COD$	$(CH_3)_3COK$	.17	70	1.5	54	51	~100% Rac.
13	C_6H_5	$CO_2C(CH_3)_3$	H[n]	.15	$(CH_3)_3COD$	$(CH_3)_3COK$	.0051	25	0.25	25	23	~100% Rac.

[a] Optically pure unless otherwise specified. [b] Leaving group, H or D. [c] M.p., 47.5–48.0° $[\alpha]^{26}{}_{546}$ −13.3° (C, 5.37, $CHCl_3$). [d] Analyzed by combustion and falling drop method to be 99% O-D. [e] Analyzed by combustion and falling drop method. [f] M.p. 47.5–48.0°, $[\alpha]^{31}{}_{546}$ −14.0 (C, 5.06, $CHCl_3$), 97% C–D by combustion and falling drop method. [g] Analyzed by combustion and falling drop method to be 99% $(O\text{–}D)_2$. [h] 92% $(CH_3)_2SO$, 8% CH_3OH by weight. [i] 87% optically pure 81% α-D, by infrared analysis (see ref. 1). [j] Corrected for lack of optical purity and incomplete deuteration of starting material. [k] 97% α-D, by combustion and falling drop method. [l] $\alpha^{22}\mathrm{D}$ +37.4° (l, 1 dm., neat), almost optically pure. [m] $\alpha^{25}\mathrm{D}$ 118.1° (l, 1 dm., neat). [n] $\alpha^{25}\mathrm{D}$ +35.6° (l, 1 dm., neat).

The second type of system, exemplified by 2-phenylbutane, probably forms a carbanion which is essentially flat, due to delocalization of charge

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[1] D. J. Cram, C. A. Kingsbury and B. Rickborn, THIS JOURNAL, **81**, 5835 (1959).

[2] Hydrogen or deuterium are only two of a number of possible leaving groups in this general reaction [see D. J. Cram, A. Langemann, J. Allinger and K. R. Kopecky, *ibid.*, **81**, 5740 (1959)] and subsequent papers of the series.

into the benzene ring. The stereochemical fate of such an intermediate would depend entirely on the symmetry properties of its environment, and would be expected to vary as the character of the solvent and of the basic catalyst were changed.

In the third type of system, exemplified by the nitrile, ester and amide of Table I, a flat carbanion is also envisioned as intermediate.[3] These intermediate anions are ambident, and probably protonate largely on the more electronegative element (oxygen or nitrogen) and produce symmetrical tautomers which in a second stage go to the more stable nitrile, ester or amide forms of the molecule. Such a sequence would invariably involve substitution with racemization as the steric course. The effects of other carbanion-stabilizing groups on the stereochemistry of hydrogen-deuterium reactions, as well as the detailed kinetics of these reactions, are under active investigation.

[3] S. K. Hsu, C. K. Ingold and C. L. Wilson [*J. Chem. Soc.*, 78 (1938)] observed that the rates of hydrogen-deuterium exchanged and of racemization of 1-phenyl-2-methyl-1-butanone in dioxane-deuterium oxide were equal to one another.

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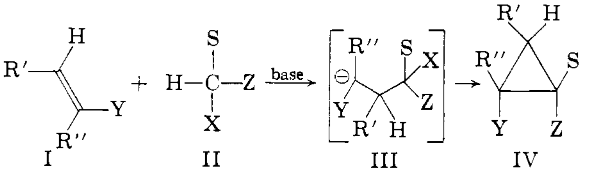
THREE MEMBERED RINGS. II. THE STEREOSELECTIVE FORMATION OF DIFUNCTIONAL CYCLOPROPANES

Sir:

A general method for the preparation of polyfunctional cyclopropanes recently has been described.[1] It generally has been observed that



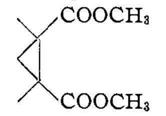
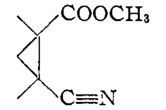
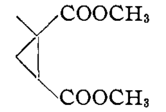
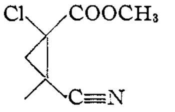
R′, R″ = H, alkyl, aryl; R′ may also be -COOR
S = H, alkyl, aryl, COOR, Cl
Y, Z = -COOR, -C≡N, $-\underset{\displaystyle O}{\underset{\|}{C}}C_6H_5$
X = Cl, Br

when only two carbons of the cyclopropane ring are substituted (IV, R′ = H), then Y and Z are oriented *cis* in the predominant or exclusive product.[1a,1c,1d,2,3,4] To explain the preference for *cis* isomer formation, the assumption has been made that there is some attractive interaction between Y and Z in an intermediate anion, III. Examination of models based on this assumption has led to the following suggestion: The presence in the reaction medium of a material which can strongly solvate III and/or the cation associated with it, and also can raise the dielectric constant of the medium, should reduce or eliminate the attractive interaction.

The suggestion has been tested by running the reaction in dimethylformamide and various mixtures of benzene and hexamethylphosphoramide.[5] The experimental conditions are those using sodium hydride described previously[1a,2] with only minor modifications. In both systems 100 ml. of solvent were used with 0.1 mole of chloride, II; the dimethylformamide reaction mixtures were filtered to remove sodium chloride and then distilled; the hexamethylphosphoramide mixtures required thorough washing to remove the amide completely from the benzene solution. Some results are summarized in Tables I and II; the results of some previously reported runs are included for comparison.

TABLE I

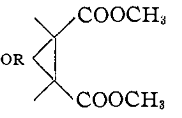
THE VARIATION OF YIELDS AND ISOMER RATIOS[a] FOR SEVERAL DIFUNCTIONAL CYCLOPROPANES PREPARED IN VARIOUS SOLVENTS

Compound	C_6H_6 or C_7H_8[b]	Dimethylformamide[b]	50% C_6H_6: hexamethylphosphoramide[b]
	71 (7)[c]	62 (66)	60 (64)[d]
	59 (25)[c]	55 (66)	
	70[e] (17)		70 (90)
	64 (20)[c]	13 (45)	65 (38)

[a] Isomer ratios were determined by gas phase chromatography; see ref. 1a. [b] The first number is the yield of mixed isomers; the number in parentheses is the percentage of *trans* isomer in the isomer mixture. [c] Ref. 1a. [d] By interpolation from results of Table II. [e] Ref. 2.

TABLE II

VARIATION OF ISOMER RATIO[a] WITH SOLVENT COMPOSITION

FOR


C_6H_6: hexamethylphosphoramide	9:1	8:2	6:4	4:6
trans:*cis*	37:63	50:50	64:36	64:36

[a] See (a), Table I.

It is quite obvious that solvent has a marked effect on the isomer ratio; the results are consistent with the proposed suggestion. It also seems reasonable to assume that with the attractive interaction of Y and Z of anion III reduced or eliminated the transition states leading to the two possible isomers

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[1] (a) L. L. McCoy, *J. Org. Chem.*, in press; (b) M. Mousseron, R. Fraisse, R. Jacquier and G. Bonavent, *Compt. rend.*, **248**, 1465 (1959); (c) R. Fraisse, *Bull. soc. chim. France*, 1102 (1959); (d) R. Fraisse and M. Guitard, *Bull. soc. chim. France*, 788 (1960); (e) D. T. Warner, *J. Org. Chem.*, **24**, 1536 (1959).

[2] L. L. McCoy, THIS JOURNAL, **80**, 6568 (1958).

[3] M. Mousseron, R. Fraisse, R. Jacquier and G. Bonavent, *Compt. rend.*, **248**, 2840 (1959).

[4] M. Mousseron, R. Fraisse, *ibid.*, **248**, 887 (1959). It is shown here that isomerization is possible under basic conditions if R″ = H in IV.

[5] (a) H. E. Zaugg, B. W. Horrom and S. Borgwardt, THIS JOURNAL, **82**, 2895 (1960); (b) H. E. Zaugg, *ibid.*, **82**, 2903 (1960).