A mixture of the radical PODM (0.100 g) and 20% oleum (50 mL) was stirred for 24 h, and the resulting dark blue solution was poured onto cracked ice and extracted with ether. The ethereal layer was washed with water, dried, and evaporated. The resulting solid (0.069 g), after digestion with CCl_4, gave a residue of the dienone **9** (0.006 g, 6%) as yellow crystals: mp 208–212 °C; UV–vis (C_6H_{12}) 213 nm, 322, 400 (sh) (ϵ 91 700, 16 600, 240); IR (KBr) 1680 (s), 1585 (w), 1545 (m), 1350 (s), 1335 (s), 1232 (m), 1150 (m), 1102 (m), 1012 (m), 810 (s), 730 (s), 692 (m), 678 (m), 670 (m), 542 (m) cm^{-1}. Anal. Calcd for $C_{19}Cl_{14}O$: C, 30.8; Cl, 67.0. Found: C, 30.5; Cl, 66.9. Evaporation of the CCl_4 extract gave a solid which on recrystallization from hexane yielded the dienone **8** (0.060 g, 62%) as yellow crystals: mp 321–362 °C dec; UV–vis (C_6H_{12}) 215 nm, 323, 400 (sh) (ϵ 93 400, 11 200, 540); IR (KBr) 1693 (s), 1530 (m), 1405 (w), 1345 (s), 1330 (s), 1232 (s), 1155 (m), 1090 (m), 1012 (m), 838 (m), 802 (m), 775 (m), 745 (m), 738 (m), 698 (m), 688 (m), 671 (m), 650 (m), 540 (s) cm^{-1}. Anal. Calcd for $C_{19}Cl_{14}O$: C, 30.8; Cl, 67.0. Found: C, 30.5; Cl, 67.1.

(2) **From the Radical PODM with Fuming HNO_3.** Radical PODM (0.300 g) was added with stirring to fuming concentrated HNO_3 (100 mL). A yellow solid was formed immediately, which was filtered, washed with water, dried, and digested with hexane to give the dienone **9** (0.211 g, 72%).

(3) **From the Chlorocarbon 3 with Oleum.** A mixture of the chlorocarbon **3** (0.090 g) and 20% oleum (50 mL) was stirred for 15 h at room temperature. The resulting dark blue solution was poured onto cracked ice and extracted with ether. The ethereal layer was washed with water, dried, and evaporated. The resulting residue (0.070 g), on recrystallization from hexane, afforded the dienone **8** (0.053 g, 63%).

Preparation of the Radical Perchloro-9-phenylfluorenyl (PPF). (1) **From the Radical PODM.** PODM (0.100 g) was heated (270–275 °C, 1 h) under argon. When the resulting mass was worked up as usual, radical PPF (0.076 g, 84%) was obtained.

(2) **From the Perchloro-2-phenyldiphenylmethane (3).** Heating the chlorocarbon **3** (0.100 g) at 260–270 °C for 30 min under argon gave radical PPF (0.065 g, 75%).

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Application of Linear Free Energy Relationships to the Curtin–Hammett Principle: Correlation between Conformational Equilibrium, Chemical Reactivity, and Product Ratios

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The Curtin–Hammett principle (CHP) was originally derived to deter relating the product ratio $[A_4]/[A_1]$ to the equilibrium distribution $k_{23}/k_{32} = K$ for the kinetic system $A_1 \leftarrow A_2 \rightleftarrows A_3 \rightarrow A_4$ (Scheme I). By use of linear free energy relationships, it is herein shown that the product ratio $[A_4]/[A_1]$ for a Scheme I system is equal to $K^{1-\alpha}$, where α is a parameter which indicates the relative sensitivity of the ratio of reaction rate constants k_{34}/k_{21} and the equilibrium constant K to substituent effects. This result then permits estimation of equilibrium constants from experimental product ratios. Applications to steric effects and conformational equilibria and to electronic effects and tautomeric equilibria are discussed.

Introduction

The Curtin–Hammett principle (CHP) is one of the most valuable concepts in conformational analysis.[1,2] Historically, it was developed in the early 1950's to discourage attempts to determine conformational equilibrium constants from product ratios. According to the CHP, in a reaction (Scheme I) involving two rapidly interconverting

Scheme I

$$A_1 \xleftarrow{k_{21}} A_2 \underset{k_{32}}{\overset{k_{23}}{\rightleftharpoons}} A_3 \xrightarrow{k_{34}} A_4$$

$$k_{23}, k_{32} >> k_{21}, k_{34}$$

conformers each of which yields a different product, the product composition is not solely dependent on the relative proportions of the two conformers, and it is determined by the difference in standard Gibbs free energies of the two reaction transition states ($\Delta G^{\ddagger}_{TS}$) (eq 1).[2] However,

$$[A_4]/[A_1] = e^{-\Delta G^{\ddagger}_{TS}/RT} \quad (1)$$

we herein wish to demonstrate that the applicability of linear free energy relationships (LFERs)[3-5] can permit a qualitative or semiquantitative determination of conformational equilibria from product ratios.

The Curtin–Hammett principle applies to the kinetic system of Scheme I. Here A_2 and A_3 are rapidly interconverting isomers in equilibrium, with the equilibrium constant given by eq 2. Originally A_2 and A_3 were considered to be conformational isomers, but for generality we also allow for tautomers, especially since it has often

$$[A_3]/[A_2] = k_{23}/k_{32} = K = e^{-\Delta G^{\circ}/RT} \quad (2)$$

(1) Curtin, D. Y. *Rec. Chem. Prog.* **1954**, *15*, 111.
(2) Seeman, J. I. *Chem. Rev.* **1983**, *83*, 83.
(3) (a) "Correlation Analysis in Chemistry"; Chapman, N. B., Shorter, J., Eds.; Plenum Press: New York, 1978. (b) "Advances in Linear Free Energy Relationships"; Chapman, N. B., Shorter, J., Eds.; Plenum Press: London, 1972.
(4) Johnson, C. D. "The Hammett Equation"; Cambridge University Press: New York, 1973.
(5) Hansch, C.; Leo, A. "Substituent Constants for Correlation Analysis in Chemistry and Biology"; Wiley: New York, 1979.

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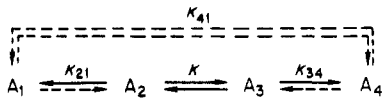
Scheme II



been noted that tautomeric ratios cannot be determined from product ratios.[6] Equation 3 is then an alternative

$$[A_4]/[A_1] = K(k_{34}/k_{21}) \quad (3)$$

(to eq 1) quantitative statement of the CHP. It is quite clear that the product ratio, $[A_4]/[A_1]$, depends not only on K but also on the ratio of reaction rate constants, so that it is not possible to determine K from the product ratio without a knowledge of k_{34}/k_{21}.

Nevertheless, if a linear free energy relationship in the form of eq 4 holds, then substitution of eq 4 into eq 3 leads

$$k_{21}/k_{34} = K^{\alpha} \quad (4)$$

$$[A_4]/[A_1] = K^{1-\alpha} \quad (5)$$

$$K = ([A_4]/[A_1])^{1/(1-\alpha)} \quad (6)$$

to eq 5 and 6, which show, respectively, that the product composition is solely dependent on the relative proportion of the two conformers and that the equilibrium constant can be determined from the product ratio. Admittedly, the product ratio dependence on the rate constants has been transformed into a dependence on α.

In the following section, we will demonstrate the validity of the conceptual sequence generalized by eq 4–6 by formal LFE derivations. We then show how α might be known or estimated, so that K can be calculated from the experimental product ratios. We will also demonstrate conceptual utilization of eq 4–6.

Derivation of Eq 4

Equation 4, and hence eq 5 and 6, can be derived from first principles. Consider Scheme II, a simple extension of Scheme I, in which a number of additional reactions are indicated by dashed arrows to indicate that these are not necessarily "observed" transformations. First, we assume that there are LFERs (eq 7 and 8) relating rates and equilibria. In these equations and the following one, the

$$k_{21} = cK_{21}^{\alpha'} \quad (7)$$

$$k_{34} = cK_{34}^{\alpha'} \quad (8)$$

equilibrium constant $K_{ij} \equiv [A_j]/[A_i]$ may not be measureable, but could be expressed in terms of free energies by $G^\circ_i - G^\circ_j = RT \ln K_{ij}$. We assume further that there is a LFER (eq 9) relating equilibrium constants K_{41} and

$$K_{41} = K^{\alpha''} \quad (9)$$

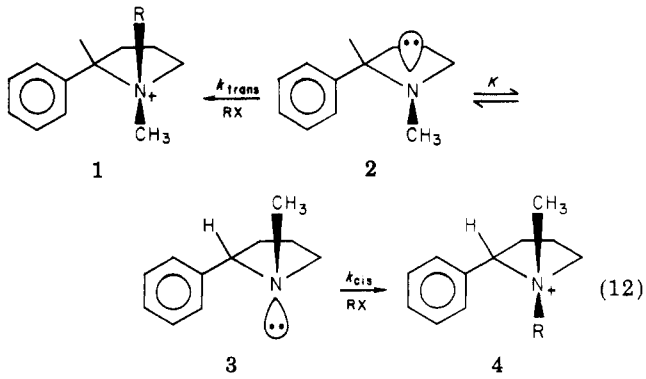
$$KK_{34}K_{41}/K_{21} = 1 \quad (10)$$

K (=K_{23}, as in eq 2). Equation 10 then follows from thermodynamics, since G is a state function. Finally, eq 7–10 lead to eq 11, which becomes equivalent to eq 4 if $\alpha \equiv \alpha'(1 + \alpha'')$.

$$k_{21}/k_{34} = (KK^{\alpha''})^{\alpha'} = K^{\alpha'(1+\alpha'')} \quad (11)$$

Applications

A. Justification. It is valuable to consider a particular example in order to discern the underlying chemical basis for eq 4–9. We have previously examined in detail the methylation of nicotine and related 1-methyl-2-arylpyrrolidines **2** ⇄ **3** (eq 12).[7-9] These alkylations have been



demonstrated to follow C–H kinetics (Scheme I and eq 1–3) in that the rates of reaction are significantly lower than the rates of nitrogen inversion. For methylation of **2** ⇄ **3**,[7,9,10] the product ratio [**4**]/[**1**] ≈ 1 even though K = [**3**]/[**2**] > 17. Consideration of eq 3 indicates that for the product ratio to be near unity the ratio of reaction rate constants must be nearly equal to K^{-1}; i.e., the large value of K must be counterbalanced by an equally small value of k_{34}/k_{21}.

From a chemical perspective, this balancing of effects if quite reasonable: (a) K is large because of a sizable steric destabilization of **2** caused by the steric interaction between the *cis*-*N*-methyl group and the aromatic ring, absent in invertomer **3**; (b) k_{34}/k_{21} is small because the incoming iodomethane molecule must approach cis to the aromatic ring in the **3** → **4** reaction but trans to the aromatic ring in the **2** → **1** reaction. The very steric factors which cause K to be large influence the ratio k_{34}/k_{21} to be small. It is this commonality of steric effects on both equilibria and rates that justifies eq 4.

B. Limiting Cases. It is instructive to consider two special cases, namely $\alpha = 1$ and $\alpha = 0$. If $\alpha = 1$, eq 5 shows that the two products are formed in equal amounts. No information about the reactant equilibrium can be deduced from the product mixture when neither product is favored.

If $\alpha = 0$, eq 5 and 6 state that the equilibrium constant is equal to the product ratio, so that K can be evaluated directly. If the reaction is unselective, both reactants will react with identical rate constants, so that the product distribution mirrors the reactant distribution. For example, reaction of photochemically generated tosylnitrene with amines has been shown to be unselective, so that conformational equilibria could be determined.[11] More commonly, a reaction is surmised to be unselective because it is diffusion controlled. Thus, protonation of amines[12-14] and of imidate anions[15] has been used to determine conformational and configurational equilibria, respectively. Strictly, these are cases of "kinetic quenching", with k_{21},

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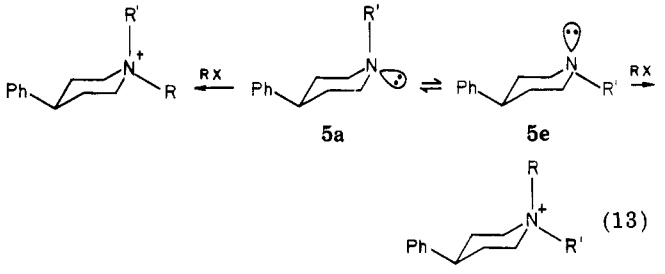
Table I. Comparison of Values of α (Eq 4) for Alkylation of Pyrrolidines (Eq 12)[a] and Piperidines (Eq 13)[b] by RX with Related Steric Substituent Constants $S°$

RX	α eq 12[a]	α eq 13: 5, R′ = Me	5, R′ = Et	5, R′ = *i*-Pr	$\bar{\alpha} \pm$ sd	$S°$ (substituent)[d]
MeX	0.78	0.70	0.81	0.85	0.79 ± 0.06	−0.73 (methyl)
EtX	1.0	0.94	0.94	0.86	0.94 ± 0.06	−1.1 (ethyl)
$PhCH_2X$	1.2	1.2	1.2	1.2	1.2 ± 0.00	−1.2 (benzyl)

[a] From ref 10a. [b] From ref 18. [c] We have used a value of $K = 99$ for the calculation of α for eq 13. Note that α is only slightly dependent on the value of K when $K > 95$. [d] From ref 26.

$k_{34} >> k_{23}, k_{32}$, so the condition that A_2 and A_3 equilibrate rapidly is not satisfied. Indeed, it is rare for this condition to hold when $\alpha = 0$, since according to the reactivity–selectivity principle[16,17] (despite its limitations), a totally unselective reaction is very fast, faster than equilibration. Nevertheless, eq 5–6, when $\alpha = 0$, hold regardless of the relative rates of equilibration and chemical reaction.

C. Steric Effects and Conformational Equilibria. In the general case, there is not the simplification of $\alpha = 0$, and it becomes necessary to know α in order to calculate K from the product distribution $[A_4]/[A_1]$. Frequently α can be determined from model reactions or for a series of reactions. For example, in alkylations of 1-methyl-2-phenylpyrrolidine (eq 12)[7,10] and 1-alkyl-4-phenylpiperidines **5** (eq 13),[18] the values of α, calculated from



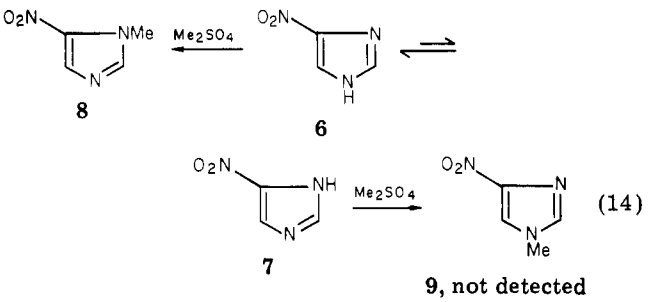
(13)

observed equilibrium constants and product ratios, are given in Table I. The regularity of values suggests that α might be transferable from one reaction to another, and that K could thereby be estimated from product ratios. Unfortunately, eq 6 is too sensitive to values of α near 1, so that quantitative estimates of K will be inaccurate for closely balanced systems.

In eq 12, the pyrrolidine nitrogen methyl group has a different steric interaction with the aromatic ring than does the reagent alkyl halide. Clearly, the former is already bonded to the nitrogen with a bond length of ca. 1.5 Å while the latter has a much smaller bond order based on the current belief[19] that the Menschutkin reaction has an early transition state (TS). The steric size or effective bulk of the N′-methyl group relative to that of the methyl moiety of the CH_3I is related to α. Modifying eq 12 or 13 by use of a more bulky, less reactive alkylating reagent would tend to increase α whereas increasing the size of the N-substituent would tend to decrease α. Thus, according to eq 5, as the alkyl halide becomes larger in size, α increases and the product ratio $[A_4]/[A_1]$ decreases. This is experimentally observed in the alkylation of a variety of pyrrolidines and piperidines with a series of alkyl halides; as the alkyl halide becomes progressively larger, more alkylation of the less stable conformation obtains.[10,12,18] The parameter α is clearly reaction dependent and is a measure of the relative stabilizing/destabilizing features of all the substituents in the $A_2 \rightleftarrows A_3$ equilibria vs. the effect of the substituents and reagents on the two product-forming reactions.

D. Electronic Effects and Tautomeric Equilibria. LFERs are notoriously imperfect for treating steric effects and conformational equilibria.[20,21] In contrast, electronic effects and tautomeric equilibria are much better behaved. If A_2 and A_3 in Scheme I are tautomeric nucleophiles, we may expect eq 3–6 to apply. Certainly the proton-transfer equilibrium between tautomers is established rapidly, so eq 3 holds. Moreover, the inductive and resonance effects on acidity or basicity, which determine the tautomeric equilibrium, also determine nucleophilicity, so that a LFER is operative. The applicability of eq 4–6, with $\alpha > 0$, to tautomeric systems becomes apparent once it is realized that A_2 and A_3 have the same conjugate acid. The relative rate constants are determined by the relative nucleophilicities of two sites, almost as the tautomeric equilibrium constant is determined by their relative basicities.

For example, methylation of 4-nitroimidazole (**6** $\rightleftarrows$ **7**) produces only 1-methyl-5-nitroimidazole (**8**) (eq 14).[22] If



(14)

a LFER is operative, this result corresponds to $\alpha \leq 0.6$. Ridd[23] has noted that the preferential formation of the less stable isomer **8** occurs because the more basic nitrogen is blocked by a proton in the predominant tautomer **6**, so that the predominant tautomer "determines" the product. Moreover, the product composition permits inferring the predominant tautomer. (One exception in this series has been attributed to a steric effect of the phenyl substituent.[24])

(16) A. Pross, *Adv. Phys. Org. Chem.* **1977**, *14*, 69.
(17) Giese, B. *Angew. Chem., Int. Ed. Engl.* **1977**, *16*, 125.
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(21) See: Seeman, J. I.; Galzerano, R.; Curtis, K.; Schug, J. C.; Viers, J. W. *J. Am. Chem. Soc.* **1981**, *103*, 5982 and references cited therein.
(22) Grimison, A.; Ridd, J. H.; Smith, B. V. *J. Chem. Soc.* **1960**, 1352, 1357.
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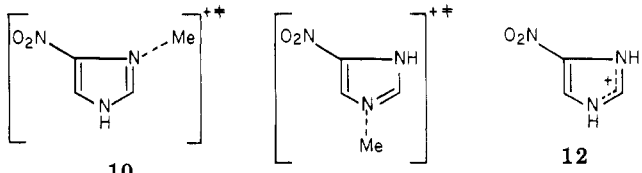
This example clarifies the operation of a LFER. The transition states for formation of **8** and **9** are **10** and **11**,



10 **11** **12**

respectively, with only a partial bond to the nucleophilic nitrogen. Such a transition state has an electronic structure intermediate between that of reactant **6** or **7** and that of their conjugate acid **12** (which is the same for the two reactants). Just as resonance and inductive effects render **6** of lower energy than **7**, so also do they render **10** of lower energy than **11**, albeit to a lesser extent, owing to the partial bond. Quantitatively, this lesser extent then leads to $0 < \alpha < 1$ in the LFER.

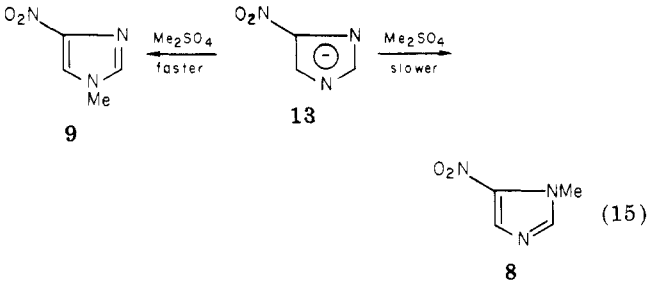
A variant on Scheme I is Scheme III, where A_5 serves as the reactive intermediate for formation of A_1 and A_4.

Scheme III

$$A_1 \xleftarrow{k_{51}} A_5 \underset{k_{25}}{\overset{k_{52}}{\rightleftharpoons}} A_2 \underset{k_{32}}{\overset{k_{23}}{\rightleftharpoons}} A_3 \underset{k_{53}}{\overset{k_{35}}{\rightleftharpoons}} A_5 \xrightarrow{k_{54}} A_4$$

Although this mechanism is possible for conformational equilibria, it is more typical with tautomeric equilibria, where A_5 is the conjugate base common to both A_2 and A_3, such that alkylation of A_5 produces two isomers, A_1 and A_4. Equation 3 still holds, with k_{21} and k_{34} the "empirical" rate constants for conversion of A_2 to A_1 and A_3 to A_4, respectively. However, in Scheme III, A_1 and A_4 correspond structurally to A_2 and A_3, respectively. This assignment reverses A_1 and A_4 from those in Scheme I. Again, eq 4–6 should hold, and the reversed assignment of A_1 and A_4 preserves $\alpha > 0$.

For example, base-catalyzed methylation of 4-nitroimidazole, via its anion **13**, produces an 8:1 mixture of 4- and 5-nitro-1-methylimidazole (eq 15),[22] corresponding to



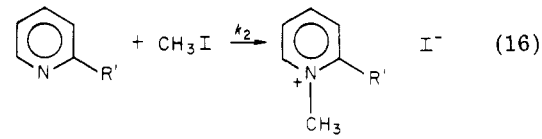
9 **13**

8 (15)

$\alpha = 0.65$. Clearly, the more basic nitrogen is the more nucleophilic. It is this parallelism that justifies the inference, from product studies, that the 4-nitro isomer **6** is the predominant tautomer. (Comparison of eq 14 and 15 shows how the assignments of A_1 and A_4 are reversed on converting from Scheme I to Scheme III). Indeed, Ridd[23] has noted that the changover of the major product corresponds to a changeover from an S_E2' mechanism (eq 14 and Scheme I) to an S_E2cB mechanism (eq 15 and Scheme III).

E. Qualitative Arguments. As in any LFER, α represents, loosely speaking, the extent to which the transition state resembles products. In any case involving tautomeric equilibria, we expect $0 < \alpha < 1$, since the partial positive charge ($\delta+$) of the transition state is less than the full positive charge acquired upon protonation. This principle is often invoked in accounting for predominant formation of the more stable product in alkylation of ambident enolates.[25] All the examples of tautomeric equilibria cited above do satisfy this condition. However, steric effects are less well behaved. In the examples of Table I, α is a measure of the size of the alkylating agent, R, at the transition state, relative to the size of R′, the N-alkyl substituent originally present. In these cases, an attacking $CH_3^{\delta+}$ or $C_2H_5^{\delta+}$ is smaller than an *N*-methyl, *N*-ethyl, or *N*-isopropyl, although $C_2H_5^{\delta+}$ can be the same size as *N*-methyl. In contrast, $PhCH_2^{\delta+}$ or $PhCOCH_2^{\delta+}$ is larger than those N-alkyl groups.

Indirect support for the identification of α as a measure of relative size can be obtained by comparison of the values determined for the four different alkylation series (Table I) with the absolute value of the steric substituent constants $S°$ determined by Gallo and co-workers from the methylations of 2-alkylpyridines (eq 16).[26] The correspondence between the average $\bar{\alpha}$ and $S°$ is remarkable. Just as $S°$ quantifies the effective size of R in the methylation reaction (eq 16), α quantifies the effective size of $R^{\delta+}$ in the alkylation reaction (eq 12) relative to the effective size of R′.



(16)

Often eq 6 cannot be applied quantitatively, but a qualitative inference of the position of the equilibrium is justified. This is especially true with tautomeric equilibria, where $0 < \alpha < 1$. Thus, for reactions that proceed according to Scheme III, the dominant tautomer is the one corresponding structurally to the major product. For reactions that proceed according to Scheme I (e.g., eq 14), the dominant tautomer is the one that leads directly to the major product (although it corresponds structurally to the minor product). Such a changeover of major product with change of mechanism (Scheme I to Scheme III) can then be taken as assurance of the correctness of the assignment of the dominant tautomer.[12] Thus it becomes possible to contravene the historical version of the CHP and assign tautomeric equilibria directly from product studies.

Even with conformational equilibria, the dominant conformer can often be assigned on the basis of product studies. All that is needed is to establish whether α is <1 or >1. The magnitude of α relative to unity can often be surmised by comparing the size of the attacking reagent with the size of the substituent already present. Thus the values in Table I suggest that $CH_3^{\delta+}$ and $C_2H_5^{\delta+}$ are smaller than alkyl groups, whereas $PhCH_2^{\delta+}$ and $PhCOCH_2^{\delta+}$ are larger, so that α might have been expected to be <1 and >1, respectively. Admittedly, such guesses are hazardous, so the existence of a changeover in product ratios generates confidence.[12] Thus the changeover in product ratios from methylation to benzylation is assurance that $\alpha < 1$ for methylation and $\alpha > 1$ for benzylation, and that the predominant conformation is the one that forms methylated product more rapidly.

F. Stereochemical Assignments. The LFER embodied in eq 5 forms the theoretical underpinning of the methodology suggested by McKenna for making stereochemical assignment of diastereomers obtained in amine quaternizations, illustrated in eq 12–13.[12] By interchanging

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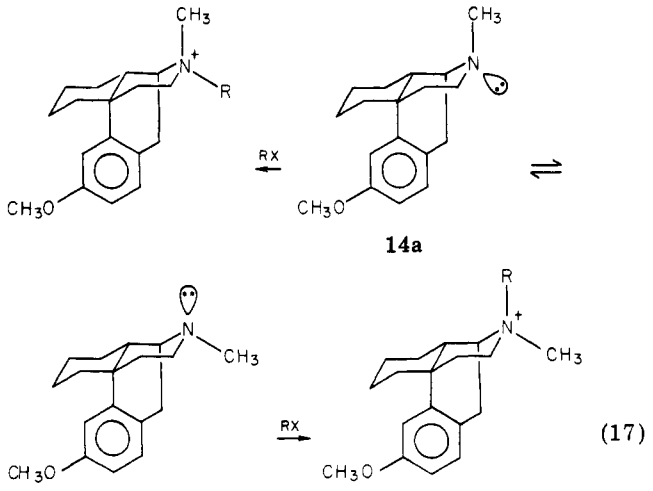
Table II. Stereoselectivity of the Quaternization of Dextromethorphan (14) by a Series of *n*-Alkyl Iodides (Eq 17)[a]

n-alkyl iodide	stereoselectivity, axial/equatorial attack	axial/equatorial ratio calcd from α (Table I)
methyl-d_3	0.14	2.6
ethyl	3.0	1.3
ethyl-d_5	4.0	1.3
propyl	3.5	
butyl	3.0	

[a] From ref 27.

the R and R′ groups, McKenna proposed that the stereoselectivities observed in pairs of eq 13 reactions would allow accurate assignment of nitrogen quaternization products. Thus, a very bulky R-substituted alkyl halide would tend to favor a decreased product ratio $[A_4]/[A_1]$ *relative* to the product ratio resulting from a smaller, more reactive RX. This follows directly from eq 4, in that a bulkier RX would influence the ratio k_{21}/k_{34} dramatically while not affecting K in Scheme I or eq 12–13.

These considerations throw into question the recent report of Wainer and Sheinin[27] on the quaternization of dextromethorphan (14) shown in eq 17 and Table II. If



(17)

we make the reasonable assumption that **14e** is more stable than **14a**, then for these alkylations to be consistent with pyrrolidine and piperidine quaternizations, the axial/equatorial product ratio should decrease with increasing bulkiness of the alkyl halide. This is not what is reported.[27] An estimation of the product ratio determined using α and eq 5 is shown in Table II. Thus, either some of the assignments are incorrect or there are special substituent effects occurring in the dextromethorphan chemistry which should be further elucidated.

Conclusions

We have herein demonstrated a conceptual extension of the Curtin–Hammett principle; namely, that under LFER conditions, the product composition $[A_4]/[A_1]$ of a chemical reaction described by Scheme I or III kinetics *is* directly related to the ground-state equilibrium distribution $[A_3]/[A_2]$ of the starting material. The relationship is of the form $[A_4]/[A_1] = K^{1-\alpha}$ (eq 5), where α is a reaction-dependent parameter which quantifies the effects of substituents on $\Delta G°$ relative to their effects on $\Delta G^{\ddagger}_{TS}$. We have derived eq 5 on the basis of LFERs. The utility of these concepts is demonstrated in terms of the reactivity of equilibrating reacting conformations and reacting tautomers, and a relationship between α and the Taft-type steric parameter $S°$ is shown. Equation 5 will find utility in qualitative comparisons, and analysis of a recent example from the literature indicates either incorrect structural assignments or the occurrence of unusual reaction stereochemistries.

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Heteroadamantanes. 3. The Effect of Changing Electron Demand on O-3 Participation in the Solvolysis of 2-Oxaadamantanes[1]

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The tosylates of *anti*-2-oxaadamantan-4-ol, *anti*-4-methyl-2-oxaadamantan-4-ol, and *anti*-4-cyano-2-oxaadamantan-4-ol have been solvolyzed in buffered acetic acid. The solvolyses yield oxaadamantyl products of exclusively retained configuration and oxaprotoadamantyl products of exclusively inverted configuration. Comparison of the CH_3/H and CN/H rate ratios with the same ratios for 2-adamantyl suggests that O-3 participation in the oxaadamantyl compounds provides anchimeric assistance of the order of 10^4.

Of late, the chemistry of heteroadamantanes has drawn much attention.[2-9] In part, this attention has been devoted to the physical properties of the solid phases of these materials, which are indicative of considerable orientational disorder.[7] On the other hand, because the adamantane

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