benzaldehyde diethyl acetal, 2403-59-0; *p*-methoxybenzaldehyde diethyl acetal, 2403-58-9; *p*-chlorobenzaldehyde diethyl acetal, 2403-61-4; methyl orthocarbonate, 1850-14-2; methyl acetate, 79-20-9.

Acknowledgment.—We are indebted to Mrs. Marjorie Kandel for recording the nmr spectra and to Professor J. C. Casanova for a helpful discussion regarding measurement of C^{13}–H coupling constants.

Chemical and Physical Properties of Some Rotational Isomers of α-Haloacetanilides. A Novel Unreactive Halogen System[1]

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A number of 2′,6′-dialkyl-2-halo-N-methylacetanilides have been shown to exist in two rotomeric forms, although the major isomer I is present in such predominate amount (85–>95%) that detection of the minor isomer II is sometimes possible only by spectral means. When one of the *ortho* substituents is *t*-butyl, I and II can each be isolated in pure, crystalline form. Structural assignments for the isomers are made on the basis of previous anilide studies, shielding effects of the anilide ring on the halomethyl group, and solvent-induced (benzene) chemical shifts observed for the NCH_3 group. From these considerations the XCH_2 group in I is assigned a position *cis* and, with *ortho* substitution, nearly orthogonal to the anilide ring; in II this group is *trans* to the aromatic ring. Although crystal lattice energy is sufficient in maintaining isomeric integrity, solutions of I and II interconvert to an equilibrium mixture *via* first-order processes. The rates of interconversion are dependent upon solvent type, with either polar or hydrogen-bonding solvents inhibiting interconversion. Steric effects are important in influencing rates as found by the decrease in order, Cl > Br > I, with, however, the greatest effect on rate from increasing *ortho* substitution by *t*-butyl groups. Equilibrium constants are not markedly affected, although there is a small increase in II with increased substitution. Differential alkylation rates are easily noted between I and II upon reaction with piperidine or pyridine. Compound II reacts relatively fast, *via* S_N2 processes in analogy to the spatially related secondary anilides III. The XCH_2 group in *ortho*-substituted I is hindered to facile approach of nucleophile. Consequently, reaction of I with amine is largely governed by a slow first-order rate-determining conversion to II, with subsequent fast alkylation by the latter isomer. As a result of the novel unreactive halogen system found in I, tertiary anilides comprised of most or all of this isomer will alkylate at considerably slower rates than secondary anilides. This effect of rotational isomerism on inhibiting alkylation rates appears to be partially operative even with tertiary anilides that rapidly equilibrate.

N-Alkyl groups in tertiary amides were found to be nonequivalent,[2] and certain of these materials, as a result of assymmetry and hindered rotation about the carbonyl carbon–nitrogen bond, are capable of existing as mixtures of *cis* and *trans* isomers. There have been a large number of reports further elucidating this phenomenon and extending the study to various different amide systems. Nonequivalence of N-alkyl groups or observance of *cis–trans* isomerism has been reported for certain N,N-disubstituted amides,[3] N-methylcyclohexylacetamide,[4] N-methyl carbamates,[5] N-alkyl lactams,[6] and certain anilides.[7] In these studies physical methods, particularly proton magnetic resonance, were utilized to elucidate configuration, equilibrium position, and energy barrier about the C(O)–N bond for isomeric mixtures of these compounds.

With the recent isolation into one or both of their pure forms, the phenomenon of rotational isomerism in amides has ceased to be a property observed only by spectral means. Thus, "*trans*"-N-methyl-N-benzylthioformamide[8] and a rotational isomer of N-benzyl-N-methylmesitylenecarboxamide[9] have been isolated pure from their respective isomeric mixtures. The more stable N-benzyl-N-methylmesitylenethiocarboxamide was separated into both pure rotational isomers,[10] as was the very hindered N-benzyl-N-methyl-2,4-6-tri-*t*-butylbenzamide.[11] In these cases, the less sterically hindered isomer was predominate, a finding well in keeping with previous studies of aliphatic tertiary amides.

Investigation of these phenomena in anilides, the subject of this report, has not always revealed such a consistent picture. Formanilide has been shown to exist in solution in both forms, but the sterically favored "*trans*" anilide (carbonyl oxygen *trans* to ring) was the predominate isomer only at low concentration.[12] Acetanilide appears to exist in only one form and, from infrared and X-ray analysis, the carbonyl oxygen is *cis* to the ring;[13] a similar configuration is reported for 2,6-diiodoacetanilide.[14] On the other hand, N alkylation appears to reverse the structure of the major isomer, although a minor isomer can be present. X-Ray examination and nmr analysis of N-methylacetanilide show carbonyl oxygen *trans* to the ring, while the minor component in solution possesses the *cis* configuration.[14] Nmr investigation of N-methyl- and N-ethylformanilide indicated a similar pattern.[15] Finally, 2,6-diiodo-N-methylacetanilide was shown to behave similarly, with the amide plane orthogonal to that of benzene. Moreover, these authors[14] claimed that the major and minor isomers could be separated, although no details were given.

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[1] Presented at the 153rd National Meeting of the American Chemical Society, Miami Beach, Fla., April 1967, Abstract O-194.

[2] H. S. Gutowsky and C. H. Holm, *J. Chem. Phys.*, **25**, 1228 (1956).

[3] L. A. LaPlanche and M. T. Rogers, *J. Am. Chem. Soc.*, **85**, 3728 (1963).

[4] R. M. Moriarty, *J. Org. Chem.*, **28**, 1296 (1963).

[5] T. M. Valega, *ibid.*, **31**, 1150 (1966).

[6] R. M. Moriarty, *ibid.*, **29**, 2748 (1964).

[7] T. H. Siddall, III, *ibid.*, **31**, 3719 (1966).

[8] W. Walter, G. Maerten, and H. Rose, *Ann.*, **691**, 25 (1966).

[9] A. Mannschreck, *Tetrahedron Letters*, 1341 (1965).

[10] A. Mannschreck, *Angew. Chem. Intern. Ed. Engl.*, **4**, 985 (1965).

[11] H. A. Staab and D. Lauer, *Tetrahedron Letters*, 4593 (1966).

[12] A. J. R. Bourn, D. G. Gillies, and E. W. Randall, *Tetrahedron*, **20**, 1811 (1964).

[13] C. J. Brown and D. E. C. Corbridge, *Acta Cryst.*, **7**, 711 (1954).

[14] B. F. Pedersen and B. Pedersen, *Tetrahedron Letters*, 2995 (1965).

[15] A. J. R. Bourn, D. G. Gillies, and E. W. Randall, *Tetrahedron*, **22**, 1825 (1966).

TABLE I

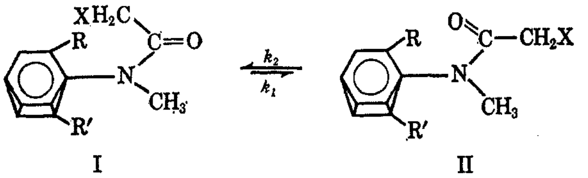
SPECTRAL ASSIGNMENTS FOR SOME PURE *cis*- AND *trans*-N-METHYLACETANILIDES

		Nmr (−ppm) from TMS[a]							
		in CCl_4		in $CDCl_3$		in C_6H_6[b]			
Material	Mp, °C	XCH_2	NCH_3	XCH_2	NCH_3	XCH_2	NCH_3	Infrared (μ) in CS_2	
I–IIa[c]	67–68.5	3.80	3.29			3.66	3.02	7.71	
Ib[b]	61–62	3.60	3.11			3.49	2.89	7.69	8.89
IIb		4.28	3.32			3.91	2.79	8.52	
Ic	42–42.5	3.62	3.14	3.76	3.24	3.57	2.91	7.70	8.92
IIc	79–80	4.02	3.22	4.21	3.35	3.82	2.79	8.53	9.20
Id	56–58	3.62	3.17	3.75	3.25			7.70	8.91
IId	87–88	4.05	3.28	4.20	3.35			8.55	9.15
Ie	45–46.5	3.48	3.13	3.60	3.24	3.44	2.98	7.71	8.92
IIe	99–101	3.85	3.30	3.94	3.30	3.61	2.82	8.62	9.10
If	64–65	3.45	3.12	3.59	3.20			7.70	8.92
IIf	105–106	3.72	3.23	3.85	3.29			8.56 8.69	9.39
Ig	149–151			3.88	3.27	3.70	2.99	7.71	12.6
IIg	143–145			4.16	3.33	3.63	2.62	8.50	9.15
Ih	147–148	3.62	3.17	3.74	3.25			7.72	9.09
IIh	110–112			3.96	3.35			8.60	9.20
Ii	160–161	3.56	3.13	3.69	3.20			7.78	9.18
IIi	138–140	3.75	3.23						9.38

[a] Amide concentration 10–20% (w/w). [b] Spectral measurements from isomeric mixture. [c] No isomerism observed; assumed concentration of Ia, >99%; see ref 14.

We wish to report our investigation of a series of N-methyl-α-haloacetanilides. This class has been disclosed by one of us to possess potent biological activity.[16] The chlor- and bromamides were obtained as a near equilibrium mixture of I (85–95%) and II (15–5%) from reaction of the appropriate authentic aniline[17] and either the acyl halide or anhydride under reflux (100–140°) or Schotten-Bauman conditions (0–25°) (Scheme I). Compounds I–IIf,i were prepared from the bromamide and sodium iodide in acetone. Some of these mixtures could well be mistaken for one compound of reasonable purity, a reason perhaps for isomers of this type having only recently been recognized. An equilibrium mixture of I and II showed only a slightly lower melting point than that for the predominate pure I. Indeed, when the energy barrier to interconversion becomes small, it is possible for the amide, as in I–IIb, to possess a sharp melting point, unchanged by crystallization from a variety of solvents, even though an equilibrium mixture of isomers is revealed by spectral analysis.

SCHEME I



I II

a, R′ = R = H; X = Cl
b, R′ = R = CH_3; X = Cl
c, R′ = t-C_4H_9; R = CH_3; X = Cl
d, R′ = t-C_4H_9; R = C_2H_5; X = Cl
e, R′ = t-C_4H_9; R = C_2H_5; X = Br
f, R′ = t-C_4H_9; R = C_2H_5; X = I
g, R′ = R = t-C_4H_9; X = Cl
h, R′ = R = t-C_4H_9; X = Br
i, R′ = R = t-C_4H_9; X = I

The remaining materials I–IIc–i, were separated into their pure *cis* and *trans* isomers by selective crystallizations from appropriate solvents. Some physical and spectral properties of these materials are listed in Table I. In series I–IIc–f, the minor isomer possessed the higher melting point; in series I–IIg–i, it had the lower melting point. In the former series II upon melting converted rapidly toward its equilibrium mixture and the resolidified sample possessed a broad and depressed melting point. On the other hand, as found in the benzamide series,[8–11] crystal lattice energy apparently is quite sufficient to maintain isomeric integrity. I–II remain essentially free of contamination from its isomer when stored as solid at room temperature or in the refrigerator.

The structural assignments for I and II are based on studies of N-alkylanilides[13–15] and our own examination of nmr chemical shifts of the groups about the amide bond. In I, the halomethyl group is *cis,* and nearly orthogonal to the benzene ring and so lies in the latter's shielding region, while the same group in II occupies a position in the deshielding zone. An approximate difference between the two of 0.6–0.9 ppm is predicted from the model of Johnson and Bovey.[18] The observed $\Delta\delta_{I-II}$ for halomethyl in chlorinated solvents is decreased somewhat with increasing alkyl substitution, from the 0.7 for I–IIb, to 0.2–0.3 ppm found for I–IIg–i. The upfield shift (shielding) of the halomethyl group in I is not inconsistent with the *downfield* shift observed for the homologous formyl proton *cis* to the ring, in N-methylformanilide.[15] In the latter anilide the amide and benzene moieties are more nearly coplanar with consequent deshielding of the formyl proton. Contrasting the chemical shift in chlorinated solvents and benzene, it is readily apparent that the resonance of the NCH_3 group is shifted to a much greater extent between the two types of solvent in II than in I. The structural

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(16) J. F. Olin, Belgian Patent 622,131 (1962); *Chem. Abstr.*, **59**, 11330*h* (1963); British Patent 1,008,851 (to Monsanto Co.) (1965).

(17) Materials characterized as 6-methyl-, 6-ethyl-, and 6-*t*-butyl-2-*t*-butylanilines [R. Stroh, J. Ebersberger, H. Haberland, and W. Hahn, *Angew. Chem.*, **69**, 124 (1957)] are actually the *p*-*t*-butyl isomers. Proof of this and properties for the authentic requisite 2,6-substituted anilines are given in the Experimental Section.

(18) C. E. Johnson, Jr., and F. A. Bovey, *J. Chem. Phys.*, **29**, 1012 (1958)

TABLE II

EQUILIBRIUM AND RATE CONSTANTS FOR INTERCONVERSION OF SOME PURE *cis*- AND *trans*-ACETANILIDES[a]

	$K \times 10^2$			$t_{1/2}$[b] hr			$k_1 \times 10^7$ sec^{-1}			$k_2 \times 10^7$ sec^{-1}		
Material	CCl_4	$CDCl_3$	Aq acetone[c]	CCl_4	$CDCl_3$	Aq acetone[c]	CCl_4	$CDCl_3$	Aq acetone[c]	CCl_4	$CDCl_3$	Aq acetone[c]
I–IIb	5.5			*d*								
Ic	7.8	4.8					25	8.9		325	184	
IIc	8.8	5.0		3.1	17		47	5.0		531	100	
Id	7.8	4.5					32	7.0		416	155	
IId	7.8	4.7	13.6	3.2	17	32	38	4.6	8.3	491	98	61
Ie	8.1	6.7					10	2.4		126	36	
IIe	9.2	7.1	16.8	12	57	81	15	2.4	4.0	160	33	24
IIe[e]	7.7			0.35			438			5670		
If	12	10					5.9	1.2		48	12	
IIf	10	10	19.0	25	138	218	7.7	1.4	1.9	76	14	9.8
Ih[f]	13.6						164			1210		
Ii[f]	13.2						165			1240		
IIi[f]	16.4			1.79			196			1190		
Ii[g]	14.9						482			3230		

[a] Except where otherwise noted, data obtained at 25 ± 1°, containing 10–20% amide (w/w). [b] Observed times elapsed for II_t = 0.5. [c] Aqueous d_6-acetone contained 15% D_2O (w/w). [d] Too fast to measure. [e] Measured at 51 ± 1° to give $E_{a(\mathrm{II} \rightarrow \mathrm{I})} = 26.3$ kcal/mole, $\Delta S_{51^\circ}^{\ddagger} < \pm 1$ eu. [f] Measured at 101 ± 1°. [g] Measured at 111 ± 1° to give $E_{a(\mathrm{II} \rightarrow \mathrm{I})} = 27.8$ kcal/mole, $\Delta S_{51^\circ}^{\ddagger} < \pm 1$ eu.

assignments are therefore supported by invoking the usual interpretation[19] that the NCH_3 group *trans* to the carbonyl oxygen has the greater difference in chemical shift. Less reliable, but nevertheless to be noted, is the difference in chemical shift observed between these two types of solvent for the halomethyl group. This group is more affected in II than in I, a fact that could possibly be rationalized on the basis of the greater ease of solvation (and hence greater shielding) of this group by benzene with the more exposed methylene protons in II.

The infrared absorptions in Table I are characteristic of spectrum differences between I and II. The medium band at *ca.* 7.7 μ is especially notable for I, since it is consistently absent in II. A qualitative measurement of change in intensity in these bands with time indicated that these materials are as unstable in carbon disulfide as in carbon tetrachloride (see below).

The data on equilibrium and kinetics of interconversion are summarized in Table II. With both pure I and II in hand it was possible to determine appropriate constants starting from either isomer. It is to be expected that data collected from conversion of II to I would be more reliable, owing to the greater accuracy associated with measuring the larger changes in concentration involved. The comparison does, however, serve to indicate that an approximation of k_1 and k_2 can be obtained by measuring equilibration rates of the more plentiful and easily isolable I. Equilibrium constants do not vary greatly, although there is a gradual increase in the minor isomer II with increased bulk about the C(O)–N bond, indicating perhaps that II represents the more sterically favored configuration [compare relative amount of IIi (*ca.* 15%) with 0.5% of spatially similar minor isomer reported for N-methylacetanilide[14]]. Rate of interconversion decreases with increased substitution, and is most notable with substitution by *t*-butyl groups. Thus substitution of an *ortho* methyl group by an *o-t*-butyl group renders the isomers isolable, while substitution of both methyl groups gives isomers that appear to be stable in solution for prolonged periods. Although the two systems are not identical, these results resemble those found in similarly substituted benzamides. Thus, I–IIi show E_a values of *ca.* 27–28 kcal/mole, lower by several kilocalories than that reported for a 2,4,6-tri-*t*-butylbenzamide.[11] Compounds Ie–IIe display E_a values *ca.* 26 kcal/mole, which is between that reported for a mesitylenecarboxamide and its more stable thio analog.[10]

Noteworthy in Table II is the effect of solvent on rate. The decrease observed may be nothing more than the result of increased solvation of the amide with increasing solvent polarity or ability to hydrogen bond. This would have the effect of either stabilizing charge separation or adding bulk about the amide bond, both factors tending to inhibit rotation. On the other hand, a more specific, unknown mode of participation by solvent is also a possibility.

Haloamides are well-known alkylating agents, and in fact, the biological activity possessed by some of them have been postulated to originate from this ability.[20] Examination of models show that I and II should differ markedly in this property; the rate of SN2 halogen displacement in I would be expected to be slower than in II because of the more hindered position of the halomethyl group. Rates of alkylation in aqueous acetone of amide with excess pyridine and piperidine were measured by following rate of halide formation. Observed pseudo-first-order rate constants, $k\psi_{\mathrm{obsd}}$, were obtained from linear plots of log [amide] *vs.* time. To determine the degree of SN2 participation (first order in amide and amine), the reactions were carried out in at least two different initial concentrations of excess amine (amine/amide = 50:1 and 20:1). If the reaction was essentially 100% SN2, $k^1\psi_{\mathrm{obsd}}$ and $k^2\psi_{\mathrm{obsd}}$ differed by a factor of 2.5, with the second-order constant, $k_3 = k\psi_{\mathrm{obsd}}/[\mathrm{amine}]$. Where first-order kinetics prevailed (alkylation independent of amine concentration) $k^1\psi_{\mathrm{obsd}}$ and $k^2\psi_{\mathrm{obsd}}$ were nearly equivalent, and no k_3 was calculated. The data thus

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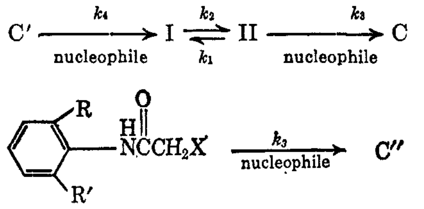
(19) J. V. Hatton and R. E. Richards, *Mol. Phys.*, **5**, 139 (1962).

(20) E. G. Jaworski, *Science*, **123**, 847 (1956).

SCHEME II[a]



$$C' \xrightarrow[\text{nucleophile}]{k_4} I \underset{k_1}{\overset{k_2}{\rightleftharpoons}} II \xrightarrow[\text{nucleophile}]{k_3} C$$

IIIa, R = R′ = H; X = Cl
b, R = R′ = CH_3; X = Cl
c, R′ = t-C_4H_9; R = C_2H_5; X = Cl
d, R′ = t-C_4H_9; R = C_2H_5; X = Br
e, R′ = t-C_4H_9; R = C_2H_5; X = I
f, R′ = R = t-C_4H_9; X = I

[a] Nucleophile = piperidine, pyridine. C and C′ = alkylation products, I–IIa–i, where X = $C_5H_5N^+$ or $C_5H_{14}N$. C″ = alkylation product, IIIa–f, where X = $C_5H_5N^+$ or $C_5H_{10}N$.

collected in Table III can more easily be interpreted by reference to Scheme II.[21]

TABLE III

RATE CONSTANTS FROM REACTION OF SOME HALOACETANILIDES WITH NUCLEOPHILES

	Rate constants[a,b] × 10^7				
	Initial amine/amide (50:1)		Initial amine/amide, 20:1		
Amide	$k^1\psi_{obsd}$, sec^{-1}	k_3, M^{-1} sec^{-1}	$k^2\psi_{obsd}$, sec^{-1}	k_3, M^{-1} sec^{-1}	%[c] SN2
I–IIa	14,000	7,800[d]	5,300	7,400[d]	100
I–IIb	674	376[d]	345	482[d]	60
Id	9.76		6.53		30
IId	390	218			
Ie	7.27		6.24		10
	5.42[e]		5.09[e]		0
IIe	30,500	17,000	10,300	14,400	100
	1,180[e]	586[e]	448[e]	544[e]	100
If	4.4		3.1		30
	2.44[e]		2.53[e]		0
IIf	19,100	10,600	6,800	9,500	100
	496[e]	246[e]	168[e]	235[e]	100
Ii	1.4[f,g]				
IIi	14	7.8			
	151[g]	80[g]			
IIIa	28,000	15,500	11,000	15,800	100
IIIb	6,300	3,500	2,500	3,500	100
IIIc	170	94	65	91	100
IIId	14,000	7,900	5,500	7,700	100
	481[e]	238[e]	189[e]	234[e]	100
IIIe	9,900	5,500	3,600	5,100	100
IIIf	64	36			
	378[g]	210[g]			

[a] Unless otherwise noted, measurements at 25 ± 1°. [b] Except where noted, amine is piperidine at 1.79 and 0.716 M, respectively. [c] Calculated as 100 × $[(k^1\psi)/(k^2\psi) - 1]/1.5$ to nearest 10% (with maximum as 100%); experimental error causes these values to be only qualitatively significant. [d] Rate constants mixture of k_1, k_3, and k_4; see Discussion. [e] Amine is pyridine at 2.05 and 0.809 M, respectively. [f] It is too slow to measure conveniently at 25°. [g] Measured at 45 ± 1°.

It is apparent that alkylation with secondary anilides (IIIa–f)[22] and the spatially related minor isomers of tertiary anilides (IId–f,i) are relatively fast and follow the usual second-order kinetics associated with many α-halocarbonyl compounds.[24] Thus, $k\psi_{obsd}$ is proportional to the change in amine concentration, such that the second-order rate constant k_3 remains virtually unchanged with varying nucleophile concentration. The rates for II and III are dependent upon kind of nucleophile, piperidine reacting more than 30 times as fast as pyridine. Moreover, the ease of halide displacement in II and III follows the usual order, Br ≅ I > Cl. Comparing the reactivities of II and III, it is seen that k_3 is 1.5–2.5 times as great for IId–f as for the respective IIIc–e, although the highly hindered IIi is somewhat less reactive than IIIf. It can be concluded from results in Table III that respective II and III react with a given nucleophile *via* the SN2 process at comparable rates (within half an order of magnitude).

On the other hand, it is obvious from Table III that I reacts in different fashion from either II or III. Although there are small changes in $k\psi_{obsd}$ with changes in amount and kind of amine, the magnitude does not approach that necessary for true second-order kinetics. Indeed, alkylation by Id–f appears to be nearly first order. There can be substantial differences in rate between respective I and II. Thus, IIe and IIf react with piperidine (50:1) at rates over 4000 times those of Ie and If, while these latter bromo and iodo compounds alkylate at an even slower rate than the respective chloro compound, Id. Referring to Table II it is seen that the measured k_1 values (aqueous acetone) are nearly equal to the respective $k\psi_{obsd}$ for Id–f, although the latter constants are generally slightly larger. These results can be reasonably interpreted as meaning that these materials react with the amines at rates largely governed by conversion of I to II (k_1), with subsequent fast reaction of II with nucleophile to form C (k_3). Because there is a slight dependence of rate on kind and concentration of nucleophile, some contribution from direct SN2 reaction of amine with I cannot be excluded, (k_4). With the weaker nucleophile pyridine (k_4 expected to be small), $k\psi_{obsd}$ varies less with concentration and is closer to k_1 than is observed with piperidine (k_4 perhaps 30 times as large as with pyridine). Determining the actual degree of k_4 participation is complicated by the uncertainty over the magnitude of change in k_1 as measured in aqueous acetone at relatively high concentration of amide from that manifested in the necessarily somewhat different solute–solvent system maintained for alkylation measurements. Nevertheless, it would appear that a fair approximation of k_1 may be measured where first-order kinetics control alkylation in suitably hindered tertiary anilides known to exist predominately as I. From this constant and the equilibrium constant, the kinetics of interconversion could thereby be obtained solely from an equilibrium mixture of I and II.

It may be surmised from rate data for Ib–IIb, that the equilibrium favoring I (95%) may be operative in slowing rate of reaction of this anilide with piperidine despite its fast interconversion rate. The observed degree of slow second-order kinetics (60%) could arise

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[21] Reactive nucleophiles have been purposely chosen at high concentrations so that I and II will react at widely different rates ($k_3 > k_1$ or k_2). Complications can arise in interpretation of the results (sometimes simplified perhaps by steady-state approximations) if k_1 and $k_2 \geq k_3$. For instance, the reactions of Id and IId with pyridine are for the most part kinetically indistinguishable (k_1 and $k_2 > k_3$).

[22] Although the configuration of the secondary anilides IIIa–f have not been rigorously proved, no isomerism is displayed and it seems reasonable to assume them to be wholly constituted with the carbonyl oxygen *trans* to the N–H. This spatial arrangement has been confirmed for a number of secondary amides and anilides, employing X-ray, infrared, and dipole moment measurements.[13,14,23]

[23] L. J. Bellamy, "The Infrared Spectra of Complex Molecules," John Wiley and Sons, Inc., New York, N. Y., 1958: (a) Chapter 12; (b) p 78.

[24] E. L. Eliel in "Steric Effects in Organic Chemistry," M. S. Newman, Ed., John Wiley and Sons, Inc., New York, N. Y., 1956, pp 103–106.

from two sources Rate constant k_4 could participate; this is possible in Ib (but less so in Id–i) because of the greatly reduced bulk surrounding the halogen. Alternatively, k_3 predominates but $k\psi_{\text{obsd}}$ is lower than that observed for IIIb because of the low effective concentration of IIb arising from the equilibrium favoring Ib. Finally, in view of the apparent equilibrium favoring Ia,[14] the relatively fast SN2 alkylation observed for this unhindered anilide could be attributed to appreciable contribution from k_4.

In any event, it is clear that depending upon alkylation conditions, substantial rate reductions, due to rotational isomerism, can be exhibited by tertiary α-haloanilides compared with their secondary homologs. This apparently holds, although to a lesser extent, with amides undergoing even relatively fast interconversion. These observations may be of some use in evaluating the alkylating ability of certain haloanilides. Conversely, judicious study of alkylation rates for variously substituted α-haloamides should provide a useful supplement to spectral methods in determining rotational properties of this class.

Experimental Section[25]

Procedures for the preparation of α-haloacetanilides (the tertiary anilides as near-equilibrium mixtures) from the respective anilines and α-haloacyl derivatives have been described elsewhere.[16] Certain literature references give erroneous data on 6-methyl, 6-ethyl-, and 6-*t*-butyl-2-*t*-butylanilines and their acyl derivatives.[17,26] Indeed, the melting points listed for the benzanilides actually correspond to those derived from the 2,4-substituted anilines. Physical properties of the authentic 2,4- and new 2,6-dialkylanilines and related compounds are listed below. Additional structure proof is afforded by examination of the infrared spectra. Thus, ArH out-of-plane deformation vibration between 680 and 860 cm^{-1} is characteristic of benzene substitution.[23b] Where external deformation from NH_2 obscured the interpretation of nuclear substitution *ca.* 740 cm^{-1}, spectra of the haloacetanilide and N-methylaniline served to verify nuclear substitution. Additional proof was garnered by comparing the 2,4- and 2,6-dialkylated anilines, where the latters' symmetric and asymmetric N–H stretching modes are more nearly of equal intensity, while the former amines displayed a third hydrogen bonded N–H stretch at lower frequency.[27]

Characterization of 4- and 6-*t*-Butyl-*o*-toluidines.—6-*t*-Butyl-*o*-toluidine [bp 116° (10 mm), n^{25}_{D} 1.5416] displayed significant bands from infrared at 740 and 770 (ArH) and 3400 and 3500 cm^{-1} (*ca.* equal intensity NH). Conversion to 6-*t*-butyl-*o*-benzotoluidide gave solid, mp 245.5–247°.

Anal. Calcd for $C_{18}H_{21}NO$: C, 80.86; H, 7.92; N, 5.24. Found: C, 80.90; H, 7.80; N, 5.20.

4-*t*-Butyl-*o*-toluidine [bp 118° (10 mm), mp 3.4°, n^{25}_{D} 1.5354], displayed significant bands from infrared at 812 (ArH) and 3300 and 3400 (nonbonded NH, latter more intense) and 3200 cm^{-1} (bonded NH). Conversion to 4′-*t*-butyl-*o*-benzotoluidide gave solid, mp 170.7–171.5°.

Anal. Calcd for $C_{18}H_{21}NO$: N, 5.24. Found: N, 5.15.

Characterization of 2- and 4-*t*-Butyl-6(2)-ethylanilines.—2-*t*-Butyl-6-ethylaniline [bp 126° (10.5 mm), n^{25}_{D} 1.5371] displayed significant bands from infrared spectra at 740 (broad, see N-methyl derivative below for absence of NH_2 deformation), 3400 and 3500 cm^{-1} (*ca.* equal intensity NH). Conversion to 2′-butyl-6′-ethylbenzanilide gave solid, mp 231.5–232.5°.

Anal. Calcd for $C_{19}H_{23}NO$: C, 81.10; H, 8.24; N, 4.98. Found: C, 81.22; H, 8.20; N, 4.96.

4-*t*-Butyl 2-ethylaniline [bp 134° (12.5 mm), n^{25}_{D} 1.5287] displayed significant bands from infrared at 815 cm^{-1} (ArH) and two unequal bands centered at 3400 (nonbonded NH), and one band at 3200 cm^{-1} (bonded NH). Conversion to 4′-*t*-butyl-2′-ethylbenzanilide gave a solid, mp 178.1–178.4°.

Anal. Calcd for $C_{19}H_{23}NO$: C, 81.10; H, 8.24; N, 4.98. Found: C, 80.69; H, 8.25; N, 4.95.

Characterization of 2- and 4,6(2)-Di-*t*-butylanilines.—Both of these anilines have been previously correctly described.[28] We have collected additional data as follow. 2,6-Di-*t*-butylaniline [bp 144–146° (13 mm), mp 49–49.5°] displayed significant bands from infrared spectra at 740 and 790 (ArH) and 3450 and 3500 cm^{-1} (NH, nearly equal intensity). Conversion to 2′,6′-di-*t*-butylbenzanilide gave solid, mp 280–281°.

Anal. Calcd for $C_{21}H_{27}NO$: C, 81.51; H, 8.79; N, 4.53. Found: C, 81.49; H, 8.77; N, 4.51.

Preparation of 6-*t*-Butyl-N-methyl-*o*-toluidine.—6-*t*-Butyl-*o*-toluidine (284 g, 1.74 moles) and 284 g (2 moles) of methyl iodide with 200 ml of acetonitrile were heated together under reflux for a period of 48 hr. At the end of this time, 250 ml of water was added and the mixture was distilled under vacuum to remove excess methyl iodide and acetonitrile. Thereafter 80 g of sodium hydroxide in 200 ml of water added, and the mixture was thoroughly agitated. Upon standing two phases were formed and the oil layer was removed and washed once with water. This material was distilled to give 291 g of an impure 6-*t*-butyl-N-methyl-*o*-toluidine, bp 110.5–112.5° (10.6 mm). Upon redistillation, 116 g (38% yield) of 6-*t*-butyl-N-methyl-*o*-toluidine was obtained, bp 110–113° (10.6 mm), n^{25}_{D} 1.5266.

Preparation of 2-*t*-Butyl-6-ethyl-N-methylaniline.—The requisite primary aniline (354 g, 2 moles) was mixed with an equal weight of acetonitrile. The mixture was refluxed (85°), and 295 g (2.07 moles) of methyl iodide was added dropwise over 1.5 hr. The mixture was further refluxed for 20 hr, 500 ml of water was added, and the mixture was distilled to a final pot temperature of 91°. The homogeneous residue was cooled to *ca.* 35° and 120 g of sodium hydroxide in 250 ml of water was added, producing an oily layer. The mixture was refluxed for 10 min and cooled, and the oil layer was separated. The oil was washed with water, dried, and then fractionated through a 4-ft packed column to give 276 g of product (95% assay by vpc), bp 138–141° (20 mm). Refractionation gave 132 g (38% yield) 2-*t*-butyl-6-ethyl-N-methylaniline, bp 138–139° (20 mm), n^{25}_{D} 1.5242. This aniline displayed significant bands from infrared spectra at 750 (ArH) and a single absorption at 3450 cm^{-1} (NH).

Anal. Calcd for $C_{12}H_{19}N$: C, 81.29; H, 10.8; N, 7.90. Found: C, 81.53; H, 11.21; N, 7.44.

Preparation of 2,6-Di-*t*-butyl-N-methylaniline.—The requisite primary aniline (103 g, 0.5 mole) was mixed with 142 g (1 mole) of methyl iodide, 150 g of anhydrous sodium carbonate, and 500 g of acetonitrile. The mixture was charged to a 1.4-l. rocking autoclave and heated for 16 hr at 115°. The cooled product, upon discharge, was filtered and the salt cake was washed with benzene. The filtrate was partially evaporated and the residue was taken up in benzene and washed with water. The material after solvent removal, was distilled to give 108 g (98% yield, assay by vpc greater than 98%) of 2,6-di-*t*-butyl-N-methylaniline, bp 65–70° (0.2 mm), n^{25}_{D} 1.5195. The secondary aniline displayed significant bands from nmr spectra (−ppm from TMS in CCl_4) at 1.45 (singlet, Ar-*t*-butyl), 2.6 (singlet, NCH_3), 2.96 (broad, NH).

Anal. Calcd for $C_{15}H_{25}N$: N, 6.38. Found: N, 6.64.

Separation of Isomers of 6′-*t*-Butyl-2-chloro-N-methyl-*o*-toluidide (Ic and IIc).—The amide, containing a near-equilibrium mixture of Ic and IIc was distilled, bp 146–148° (0.9 mm), to give 15 g of oil, n^{25}_{D} 1.5398. The distillate was dissolved in 200 ml of pentane and placed in the freezer chest (−15°) for 2 hr. The crystals that formed were separated and triturated with fresh, cold pentane to give pure Ic. The supernatant liquid was left in the freezer overnight to give *ca.* 0.4 g fine needles of IIc. Additional amounts of IIc were obtained when the pentane solution remained for prolonged periods at −15°.

Anal. Calcd for $C_{14}H_{20}ClNO$: Cl, 13.97. Found (Ic–IIc): Cl, 13.78.

Separation of Isomers of 2′-*t*-Butyl-2-chloro-6′-ethyl-N-methylacetanilide (Id and IId).—Twenty grams of a 9:1 mixture of Id and IId (mp 56–58°) was placed in 250 ml of pentane and cooled at −15° for *ca.* 50 min, after which the supernatant liquid was removed leaving crystals of pure Id. The pentane solution was

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(25) Melting points are corrected and taken on a Fisher-Johns block. The spectral instruments employed were a Beckman IR-IV and -Va, and a Varian Model A-60 nmr. Potentiometric titrations employed a Leeds and Northup combination pH and millivolt meter, no. 7664.

(26) J. Effront, *Ber.*, **17**, 2340 (1884); "Beilstein," **12**, 1180.

(27) T. F. Page, Jr., and D. R. Beasecker, Monsanto Co., unpublished.

(28) J. Burgers, W. van Hartingsveldt, J. van Keulen, P. E. Verkade, H. Visser, and B. M. Wepster, *Rec. Trav. Chim.*, **75**, 1327 (1956).

then cooled further for 2 hr, the resulting needles that formed being triturated with pentane to give 0.7 g of pure IId.

Anal. Calcd for $C_{15}H_{22}ClNO$: C, 67.27; H, 8.28; Cl, 13.24. Found (Id): C, 67.49; H, 8.39; Cl, 13.41. Found (IId): C, 67.91; H, 8.54; Cl, 13.75.

Separation of Isomers of 2-Bromo-2′-*t*-butyl-6′-ethyl-N-methylacetanilide (Ie and IIe).—A 9:1 mixture of Ie and IIe (20 g), was dissolved in *ca.* 200 ml of hexane and allowed to stand at room temperature for 16 hr, during which time crystals formed. After decanting the hexane solution, the crystals were triturated with pentane to give pure IIe. The hexane solution was cooled to −15° for 3–4 hr. The crystals that formed were filtered off, and by nmr were proved to be 97% Ie (3% IIe). Purity of Ie was not improved by further recrystallization from pentane. One recrystallization from cold, aqueous methanol gave pure Ie.

Anal. Calcd for $C_{15}H_{22}BrNO$: C, 57.69; H, 7.10; Br, 25.59. Found (Ie): C, 57.74; H, 7.21; Br, 25.69. Found (IIe): C, 57.32; H, 7.02; Br, 25.43.

Separation of Isomers of 2′-*t*-Butyl-6′-ethyl-2-iodo-N-methylacetanilide (If and IIf).—The oily crystals obtained from metathesis of I–IIe with sodium iodide, contained upon nmr examination *ca.* 8:2 of If and IIf. This material was dissolved in hexane, whereupon crystals of IIf formed within the hour at room temperature. Trituration with pentane gave pure IIf. The supernatant hexane solution was partially evaporated and cooled by a Dry Ice–acetone mixture. The crystals so obtained were recrystallized from aqueous methanol (−15°) to give pure If.

Anal. Calcd for $C_{15}H_{22}INO$: C, 50.15; H, 6.17; I, 35.33. Found (If): C, 50.40; H, 6.26; I, 35.18. Found (IIf): C, 50.20; H, 6.45.

Separation of Isomers of 2-Chloro-2′,6′-di-*t*-butyl-N-methylacetanilide (Ig and IIg).—The material obtained by reaction of chloroacetyl chloride with 2,6-di-*t*-butyl-N-methylaniline appeared to contain, besides 85:15 parts of Ig and IIg, some 2-chloro-2′-*t*-butyl-N-methylacetanilide, apparently arising from debutylation during formation of Ig–IIg. The mixture was recrystallized from heptane at room temperature to give pure Ig. To obtain IIg, several grams of pure Ig was heated for 6 hr in refluxing chlorobenzene, to rearrange *ca.* 10% Ig to IIg. The solid obtained by evaporation of solvent was then recrystallized from aqueous methanol to give, after standing in the cold, pure Ig. The residue obtained by evaporating the supernatant, aqueous methanol showed enrichment in IIg, which was made pure by a final recrystallization from hexane.

Anal. Calcd for $C_{17}H_{26}ClNO$: Cl, 11.98; N, 4.74. Found (Ig): Cl, 12.30; N, 4.81.

Separation of Isomers of 2-Bromo-2′,6′-di-*t*-butyl-N-methylacetanilide (Ih and IIh).—The crude reaction mixture was found to contain the demethylated anilide homolog as well as a near-equilibrium mixture of Ih and IIh. The material was treated with boiling hexane and filtered while hot to remove the secondary anilide. On cooling, pure Ih was formed as crystals. Ih (4g) was heated for 12 hr in refluxing chlorobenzene to give 87% Ih and 13% IIh. The residue, after solvent removal, was recrystallized from hexane at room temperature to give pure Ih. The supernatant hexane solution was vacuum treated to remove solvent, and the residue was recrystallized from aqueous methanol (−15°) to give additional pure Ih. The supernatant aqueous methanol solution was vacuum treated at room temperature to remove methanol. The resulting solid contained 75–85% IIh, which was obtained pure (0.3 g) after drying by recrystallization from hexane.

Anal. Calcd for $C_{17}H_{26}BrNO$: Br, 23.48; H, 4.12. Found (Ih): Br, 23.55; N, 4.07. Found (IIh): Br, 24.12; N, 4.24.

Separation of Isomers of 2′,6′-Di-*t*-butyl-2-iodo-N-methylacetanilide (Ii and IIi).—The crude reaction mixture was prepared by heating 18.8 g of Ih–IIh in a 300-ml autoclave with 200 ml of acetone and 20 g of sodium iodide for 15 hr at 125°. The material prepared in this fashion was treated to remove solvent, and the residue was taken up in benzene, washed with water, and very dilute sodium bisulfite. The benzene solution was evaporated to give 22 g of residue. Three components were evident from the nmr spectra with Ii and IIi predominating in an 80:20 ratio. The mixture was recrystallized from heptane (charcoal) at room temperature, followed by recrystallization from aqueous methanol at room temperature to give 7.8 g pure Ii. Compound Ii was refluxed in chlorobenzene for 2 hr to give, from the nmr spectra, a mixture of Ii and IIi (85:15). After solvent removal, the residue was recrystallized from hexane at room temperature to give Ii. The hexane solution was evaporated to give a 60:40 ratio IIi:Ii. This material was dissolved in aqueous methanol and allowed to stand at −15° for 3 days to give pure Ii. After methanol removal of the supernatant solution, the residue was dried and recrystallized from cold hexane to give pure IIi.

Anal. Calcd for $C_{17}H_{26}INO$: I, 32.77; N, 3.62. Found (Ii): I, 32.65; N, 3.66. Found (IIi): N, 3.76.

2′-*t*-Butyl-2-chloro-6′-ethylacetanilide (IIIc).—Reaction of 2-*t*-butyl-6-ethylaniline with chloroacetyl chloride in boiling toluene[16] yielded solid, which upon recrystallization from aqueous methanol gave product mp 98.8–100.2°.

Anal. Calcd for $C_{14}H_{20}ClNO$: Cl, 14.79. Found: Cl, 14.76.

2-Bromo-2′-*t*-butyl-6′-ethylacetanilide (IIId).—Using bromoacetyl bromide as the acylating agent, in a procedure identical with that given above for IIIc, crystals, were obtained, mp 163.2–163.8°.

Anal. Calcd for $C_{14}H_{20}BrNO$: Br, 26.80. Found: Br, 27.03.

2′-*t*-Butyl-6′-ethyl-2-iodoacetanilide (IIIe).—Reaction of 2-*t*-butyl-6-ethylaniline with iodoacetyl chloride at or below room temperature under Schotten–Bauman conditions, in the presence of aqueous potassium carbonate and benzene, yielded product, which after recrystallization from methanol, gave crystals, mp 168–170°.

Anal. Calcd for $C_{14}H_{20}INO$: I, 36.76. Found: I, 36.56.

2′,6′-Di-*t*-butyl-2-iodoacetanilide (IIIf).—Metathesis of 2′,6′-di-*t*-butyl-2-chloroacetanilide with excess sodium iodide in acetone, confined in a pressure vessel at 140°, gave after 5 hr the desired anilide. Recrystallization from propyl alcohol gave crystals, mp 250–251° dec.

Anal. Calcd for $C_{16}H_{24}INO$: I, 34.00. Found: I, 33.80.

Determination of Interconversion Rate (I and II).—Pure crystalline I or II was dissolved in the appropriate solvent and zero time was recorded. The solution was then placed in a sealed nmr tube and at intervals momentarily inserted in the nmr probe, and the relative areas were measured under the absorption peaks corresponding to the XCH_2 and NCH_3 resonances of I and II. The relative amounts of I and II were thereby ascertained for any time t (I_t and II_t). The equilibrium constant K was determined from relative equilibrium amounts (I_e and II_e) established after permitting the solution to stand for at least 10 times the observed half-life of the reaction. The data were then treated, assuming a first-order rate for forward and reverse reaction by a linear plot (least-square method) of log ($I_t - I_e$) *vs.* t. From the slope and K, k_1 and k_2 were calculated.[8,9,29] Points making up the straight lines (average of seven per line) were obtained from observations extending over at least two-thirds of the equilibration. Correlation coefficients (r) calculated from linear plots of all equilibrations derived from II listed in Table II averaged 0.997 ± 0.002. From linear plots of all equilibrations derived from I given in Table II, r averaged 0.96 ± 0.03, demonstrating the lesser reliability associated with this latter rate measurement.

Determination of Nucleophilic Substitution Rate (I, II, and III).—Compound I, II, or III was added at zero time to the following solution: water (0.12 g/ml), excess amine (the amount depending upon the desired ratio of amine to amide), acetone (to a final volume, such that the exactly known initial concentration of amide, A_0, was between 0.03 0.04 M). The ratio of amine to amide was always high enough that a pseudo-first-order rate constant ($k\psi_{obsd}$) could be measured, although it was established with pilot runs that, when the reaction was truly governed by S$_N$2, the second-order rate constant k_3, derived from $k\psi_{obsd}$, remained essentially constant between ratios of initial amine/amide concentrations of from 5:1 to 60:1. One-half-milliliter aliquots of the solution were withdrawn at time t, and pipetted into 50 ml of an acid solution (pH 2–3 with H_2SO_4) containing *ca.* 45 ml of acetone and 5 ml of water. It was determined that the reaction was completely arrested at this stage. Free halide concentration at time t ($[Hal_t]$) was then determined by potentiometric method with 0.005 N silver nitrate. A straight line was obtained by plotting log ($A_0 - [Hal_t]$) *vs.* t (least-square method). From the slope of this line, $k\psi_{obsd}$ (sec^{-1}) was obtained. Where significant, k_3 (M^{-1} sec^{-1}) was calculated from $k\psi_{obsd}$/[amine]. Points making up the linear plots (average of seven per line) were obtained from determinations extending over at least two-thirds of the alkylation reaction. Correlation coefficients (r), calculated from linear plots of all

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[29] A. P. ter Borg and H. Kloosterziel, *Rec. Trav. Chim.*, **82**, 741 (1963).

alkylation reactions listed in Table III, averaged 0.998 ± 0.002. Where duplicate determinations of rate constants were measured, an average deviation of ± 2% was obtained.

To demonstrate that the rate measurements applied to a reaction involving simple replacement of the α-halogen with the amino group, (Scheme II), the following experiment was carried out. 2′-*t*-Butyl-2-bromo-6′-ethylacetanilide (IIId, 4.0 g, 0.013 mole) was placed in a mixture containing 22.5 g of piperidine (0.26 mole) and 45 g of water. The solution was brought to a total volume of 375 ml with acetone, then permitted to stand at room temperature for 4 hr. The material was vacuum treated to remove solvent; then water was added and the white, crystalline solid was filtered off. The dried product (4.1 g, quantitative yield) possessed mp 155–155.5°, unimproved by crystallization as needles from aqueous methanol. Nmr and infrared spectra were shown to be consistent with the structural assignment as 2′-*t*-butyl-6′-ethyl-2-(1-piperidyl)acetanilide.

Anal. Calcd for $C_{19}H_{30}N_2O$: C, 75.45; H, 10.00; N, 9.26. Found: C, 75.18; H, 10.12; N, 9.60.

Registry No.—Ia, 13117-74-3; Ib, 13117-75-4; Ic, 13117-76-5; Id, 13117-77-6; Ie, 13117-78-7; If, 13117-79-8; Ig, 13135-43-8; Ih, 13117-80-1; Ii, 13117-81-2; IIb, 13117-82-3; IIc, 13117-83-4; IId, 13117-84-5; IIe, 13117-85-6; IIf, 13117-86-7; IIg, 13117-87-8; IIh, 13117-88-9; IIi, 13117-89-0; IIIa, 587-65-5; IIIb, 1131-01-7; IIIc, 13117-92-5; IIId, 13117-93-6; IIIe, 13143-69-6; IIIf, 13143-70-9; 6-*t*-butyl-*o*-toluidine, 13117-94-7; 6-*t*-butyl-*o*-benzotoluidide, 13117-95-8; 4′-*t*-butyl-*o*-benzotoluidide, 13117-96-9; 2-*t*-butyl-6-ethylaniline, 13117-97-0; 2′-*t*-butyl-6′-ethylbenzanilide, 13117-98-1; 4-*t*-butyl-2-ethylaniline, 13117-99-2; 4′-*t*-butyl-2′-ethylbenzanilide, 13118-00-8; 2′,6′-di-*t*-butylbenzanilide, 13118-01-9; 6-*t*-butyl-N-methyl-*o*-toluidine, 13143-71-0; 2-*t*-butyl-6-ethyl-N-methylaniline, 13118-02-0; 2,6-di-*t*-butyl-N-methylaniline, 13118-03-1; 2′-*t*-butyl-6′-ethyl-2-(1-piperidyl)acetanilide, 13143-72-1, 4-*t*-butyl-*o*-toluidine, 2909-82-2; 2,6-di-*t*-butylaniline, 2909-83-3.

Nitration Studies. XV. Nitromercuration and the Synthesis of β-Nitromercurials[1]

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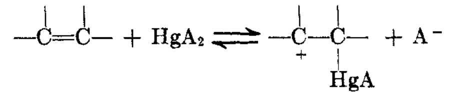
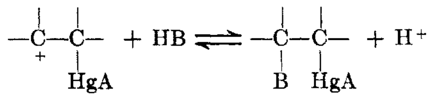
Olefins react with solutions containing mercuric and nitrite ions to form β-nitroalkylmercuric salts. Conversions and rates depend markedly on concentrations of the above ions, which in turn are highly dependent on the concentrations of counterions, and on the structure of the olefin. The complex and mobile equilibria involved are readily disturbed by acids, bases, reducing reagents, and other substances with regeneration of the olefin or its polymers. The remarkable predominance of the entrance of the nitrite ion into the product as a nitro group rather than as a nitrite ester group is discussed.

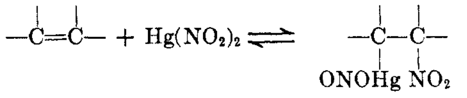
Addition to olefins is one of the most characteristic reactions of mercuric salts[3] but one of the least characteristic reactions of salts of other metals. No other metal approaches mercury in the ease with which such additions take place and in the stability of the products. However, the addition of the mercuric ion must also be accompanied by the addition of a negative ion, and the synthetic possibilities which this engenders have not been adequately developed. This paper is concerned with an evaluation of such possibilities in the specific case of the negative ion NO_2^-. As an ambident anion[4] NO_2^- may attach itself to a carbonium ion either *via* an oxygen atom to form a nitrite ester or *via* the nitrogen atom to form a nitro compound. A matter of interest is, therefore, the influence of the mercuric ion on the way in which the NO_2^- ion enters the molecule.



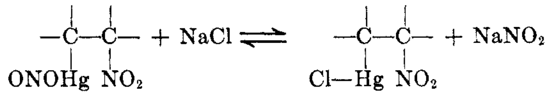
$$-\overset{|}{C}=\overset{|}{C}- + \mathrm{HgA_2} \rightleftharpoons -\overset{|}{\underset{+}{C}}-\overset{|}{\underset{\mathrm{HgA}}{C}}- + \mathrm{A^-} \tag{1}$$



$$-\overset{|}{\underset{+}{C}}-\overset{|}{\underset{\mathrm{HgA}}{C}}- + \mathrm{HB} \rightleftharpoons -\overset{|}{\underset{\mathrm{B}}{C}}-\overset{|}{\underset{\mathrm{HgA}}{C}}- + \mathrm{H^+} \tag{2}$$



$$-\overset{|}{C}=\overset{|}{C}- + \mathrm{Hg(NO_2)_2} \rightleftharpoons -\overset{|}{\underset{\mathrm{ONOHg}}{C}}-\overset{|}{\underset{\mathrm{NO_2}}{C}}- \tag{3}$$



$$-\overset{|}{\underset{\mathrm{ONOHg}}{C}}-\overset{|}{\underset{\mathrm{NO_2}}{C}}- + \mathrm{NaCl} \rightleftharpoons -\overset{|}{\underset{\mathrm{Cl-Hg}}{C}}-\overset{|}{\underset{\mathrm{NO_2}}{C}}- + \mathrm{NaNO_2} \tag{4}$$

Additions of mercuric salts to olefins are normally run in hydroxylic solvents to attain adequate solubility of the mercuric salt. However, under such circumstances the solvent rather than the anion of the salt usually enters the product molecule. In this way a variety of hydroxy, alkoxy, acyloxy, and related oxymercurials have been prepared from mercuric chloride, nitrate, or acetate in water, alcohols, and carboxylic acids.[3] However, it was recently reported[5] that mercuric nitroformate adds as such to olefins without involving the solvent (water). We have found that mercuric nitrite does the same and gives β-nitroalkyl mercuric salts provided that the reaction medium is sufficiently acidic to prevent oxymercuration. This novel synthesis of nitro compounds may be termed *nitromercuration*. Since the reaction seems to be peculiarly sensitive to conditions, we have studied various factors influencing conversions and yields, including the formulation of the nitromercurating reagent, the structure of the olefin, the nature of the solvent, the pH, the effects of other anions and cations, and the changes produced by changes in the concentrations of the reactants. From these data it has been possible to formulate a mecha-

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(1) From the Ph.D. Thesis of M. L. Whitehouse, Purdue University, Aug 1966.

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