attractive. The very low activation energy for the isomerization of bicyclo[2.2.0]hexane may offer an indication of the concerted nature of this reaction. For this reason it would be extremely valuable to have a reliable thermodynamic determination of the bridgehead bond dissociation energy. The low activation energies for the isomerization of cyclobutene and its derivatives[41,42] is strong evidence in favor of concerted electronic rearrangement in these reactions.

Acknowledgments.—We are pleased to acknowleged generous support by the National Science Foundation through Grant G-14049.

Our thanks are due to Professor Robert F. Hutton for obtaining the nuclear magnetic resonance spectrum of III and to Messrs. D. B. Harrington and D. C. Damoth of the Mass Spectrometry Laboratory, Bendix Corporation, for obtaining the spectrum of bicyclo-[2.2.0]hexane.

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, BRIGHAM YOUNG UNIVERSITY, PROVO, UTAH]

The Mechanistic Fate of the Anilino Moiety in the Rearrangement of α-Anilinoketones[1]

BY K. LEROI NELSON, JEROLD C. ROBERTSON,[2] AND JOHN J. DUVALL[2]

RECEIVED DECEMBER 27, 1962

Mass spectrographic analysis of the product mixture obtained from the competitive rearrangement of 2-(4-bromoanilino)-1-(4-bromophenyl)-2-(4-methoxyphenyl)-1-ethanone and 2-(4-chloroanilino)-1-(4-chlorophenyl)-2-(4-methoxyphenyl)-1-ethanone in the presence of γ-picoline hydrobromide clearly indicated the presence of fragments containing both bromine and chlorine in the same fragment. Analysis of a mechanical mixture of the two ketones showed no crossover fragments as indicated by the simple superposition of their respective mass spectra. These results substantiate the mechanism proposed by Nelson and Seefeld.[3] Thus, the migration of carbonyl oxygen is intramolecular while migration of the anilino moiety is clearly intermolecular. 2-(4-Chloroanilino)-1-(4-chlorophenyl)-2-propanone was rearranged to 1-(4-chloroanilino)-1-(4-chlorophenyl)-2-propanone in the presence of *p*-chloroaniline hydrobromide but not with pyridine hydrobromide or γ-picoline hydrobromide. Reverse rearrangements were unsuccessful with 1-(4-chloroanilino)-1-(4-chlorophenyl)-2-propanone, 1-(4-bromoanilino)-1-(4-bromophenyl)-2-propanone, and 1-(3-chloroanilino)-1-(3-chlorophenyl)-2-propanone using γ-picoline hydrobromide.

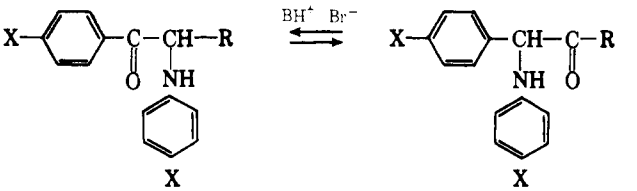
In the first paper of this series[3] we enumerated several different mechanistic schemes which have been proposed for the rearrangements of α-arylaminoketones and reported experimental work which demonstrated the intramolecular migration of carbonyl oxygen. We then proposed a mechanism involving an aminoepoxide intermediate which would allow intramolecular migration of the carbonyl oxygen and require an intermolecular migration of the anilino moiety. This proposal was consistent with the report of Weygand and Richter[4] who treated phenacylaniline with aniline (C-14) or *m*-bromoaniline (Br-82) and the arylamine salt which is usually added as a catalyst. They found that the labeled aniline was equally distributed between the resulting indole and the aniline remaining.

Recently, Stevens and co-workers[5] reported that α-bromopropiophenone reacted with methylamine to form the rearranged α-aminoketone. In a procedure similar to that used by us[3] they utilized O-18 as a tracer to demonstrate that the migration of carbonyl oxygen was intramolecular. They similarly proposed an aminoepoxide intermediate. The reaction stops at the hydroxyimine stage with compounds which lack the necessary α-hydrogen to permit tautomeric conversion to the aminoketone. Under vigorous conditions (185–250°) α-aminoketones containing no α-hydrogens undergo skeletal rearrangement.[6]

The rearrangement appears to require a mild acid since it does not occur under strictly neutral or alkaline conditions.[7,8] The necessity of free amine is suggested by the failure of the hydrochloride salt of the aminoketone to rearrange,[8] the great difference in reaction rates between aniline and pyridine,[3] and the failure to rearrange with N,N-dimethylaniline.[9] The finding that an α-C–N bond is easily cleaved under strong acid conditions might provide "free" amine[10] for rearrangements under acid conditions in the absence of added amine.[8,9]

Discussion of Results

We prepared several halogen-labeled α-aminoketones I and II for use in competitive rearrangement experiments to check the claim of Cowper and Stevens[11] that the reaction involved intramolecular migration of the aniline moiety. This seemed unlikely to us when we had clearly demonstrated that the carbonyl oxygen migrates intramolecularly.[3]



Ia, R = CH_3, X = Cl
b, R = CH_3, X = Br
c, R = 4-$CH_3OC_6H_4$, X = Cl
d, R = 4-$CH_3OC_6H_4$, X = Br

IIa, R = CH_3, X = Cl
b, R = CH_3, X = Br
c, R = 4-$CH_3OC_6H_4$, X = Cl
d, R = 4-$CH_3OC_6H_4$, X = Br

Using pyridine hydrobromide or γ-picoline hydrobromide we were unable to convert any detectable amount of Ia to IIa. With the view that conjugation of the halogen with the carbonyl group was a stabilizing factor which effectively set the equilibrium position to the far left, we prepared IIa and IIb but found they also failed to rearrange to Ia and Ib, respectively. We

(1) The Mechanism of the Möhlau–Bischler Indole Synthesis. II.

(2) This paper is based in part upon work reported in dissertations submitted to the Graduate School of Brigham Young University in partial fulfillment of the requirements for the Ph.D. Degree. It was presented before the Organic Division, 139th National Meeting of the American Chemical Society, St. Louis, Mo., March 28, 1961.

(3) K. L. Nelson and R. L. Seefeld, *J. Am. Chem. Soc.*, **80**, 5957 (1958).

(4) F. Weygand and E. Richter, *Ber.*, **88**, 499 (1955).

(5) C. L. Stevens, P. Blumberge, and M. E. Munk, Abstracts of Papers, 141st National Meeting of the American Chemical Society, Washington, D. C., March, 1962, p. 14-O.

(6) C. L. Stevens, R. D. Elliot, B. L. Winch, and I. L. Klundt, *J. Am. Chem. Soc.*, **84**, 2272 (1962).

(7) S. N. McGeoch and T. S. Stevens, *J. Chem. Soc.*, 1032 (1935).

(8) F. Brown and F. G. Mann, *ibid.*, 847, 858 (1948).

(9) P. L Julian, E. W. Meyer, A. Magnani, and W. Cole, *J. Am. Chem. Soc.*, **67**, 1203 (1945).

(10) N. J. Leonard and R. C. Sentz, *ibid.*, **74**, 1704 (1952).

(11) R. M. Cowper and T S. Stevens, *J. Chem. Soc.*, 1041 (1947).

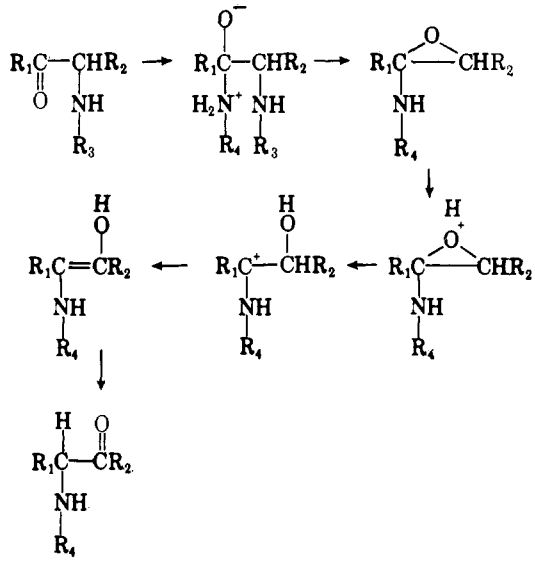
TABLE I: COMPOUNDS SYNTHESIZED IN THIS STUDY

	Compound	B.p., °C. (mm.)	n_D	Crystals	M.p., °C.	Yield, %	Source
1	*p*-Chloropropiophenone				34.5–36		As purchased
2	α-Bromo-*p*-chloropropiophenone			White	78.5–80[a]	65	From 1
3	2-(4-Chloroanilino)-1-(4-chlorophenyl)-1-propanone[b]			Yellow needles from 95% EtOH	97.0–98.5	50	From 2
4	*p*-Bromopropiophenone			White needles from Skelly A	45–46[c]	52	From bromobenzene
5	α,*p*-Dibromopropiophenone			White	82–83[d]	96	From 4
6	2-(4-Bromoanilino)-1-(4-bromophenyl)-1-propanone[e]			Yellow prisms or needles	93–94	70	From 5
7	*m*-Nitropropiophenone			White prisms from 95% EtOH	98–100[f]	53	From propiophenone
8	*m*-Aminopropiophenone hydrochloride			Buff powder	176–178[g]	74	From 7
9	*m*-Chloropropiophenone			White needles from 95% EtOH	44.5–45.5[h]	76	From 8
10	α-Bromo-*m*-chloropropiophenone[i]	124–130 (2–3)	1.5771^{25}			81	From 9
11	2-(3-Chloroanilino)-1-(3-chlorophenyl)-1-propanone[j]			Yellow prisms from 95% EtOH	70.5–71.5	44	From 10
12	1-(4-Chlorophenyl)-2-nitropropene-1[k]			Yellow prisms from 95% EtOH	85–86.5	38	From *p*-chlorobenzaldehyde
12a	1,2-Dibromo-1-(4-chlorophenyl)-2-nitropropane[l]			Prisms from CS_2	69–70	95	From 12
13	*p*-Chlorophenylacetone	105–110 (3)	1.5320^{25}			52	From 12
14	1-Bromo-1-(4-chlorophenyl)-2-propanone	85–140 (2)	$1.55–1.57^{25}$	Pale yellow		80	From 13
15	1-(4-Chloroanilino)-1-(4-chlorophenyl)-2-propanone[m]			White needles from 95% EtOH	78–79	50	From 14
16	1-(4-Bromophenyl)-2-nitropropene-1[n]			Yellow prisms from 95% EtOH	86–87	37	From *p*-bromobenzaldehyde
17	*p*-Bromophenylacetone	80–84 (1)	1.5553^{25}	Pale yellow		45	From 16
18	1-Bromo-1-(4-bromophenyl)-2-propanone	100–130 (1)	$1.59–1.61^{25}$			60	From 17
19	1-(4-Bromoanilino)-1-(4-bromophenyl)-2-propanone[o]			White needles from 95% EtOH	89–90	15	From 18
20	1-(3-Chlorophenyl)-2-nitropropene-1[p]	93–99 (1)	1.6087^{20}			48	From *m*-chlorobenzaldehyde
21	*m*-Chlorophenylacetone[q]	82–86 (1)	1.5351^{20}			60	From 20
22	1-Bromo-1-(3-chlorophenyl)-2-propanone	100–161 (1)	$1.56–1.58^{20}$			85	From 21
23	1-(3-Chloroanilino)-1-(3-chlorophenyl)-2-propane[r]			White needles from 95% EtOH	80–82	17	From 22
24	*p*-Chlorobenzanisoin			White leaflets from 95% EtOH	80.6–82.8[s]	11	From *p*-chlorobenzaldehyde and anisaldehyde
25	2-(4-Chloroanilino)-1-(4-chlorophenyl)-2-(4-methoxyphenyl)-1-ethanone[t]			Yellow needles from 2-butanone–MeOH	138.5–140	52	From 24
26	2-(4-Chloroanilino)-2-(4-chlorophenyl)-1-(4-methoxyphenyl)-1-ethanone[u]			Yellow crystals from 95% EtOH	127–127.2		From 25
27	*p*-Bromobenzanisoin			White needles 95% EtOH	67	26	From *p*-bromobenzaldehyde and anisaldehyde
28	2-(4-Bromoanilino)-1-(4-bromophenyl)-2-(4-methoxyphenyl)-1-ethanone[v]			Yellow needles from 2-butanone–MeOH	166	19	From 26

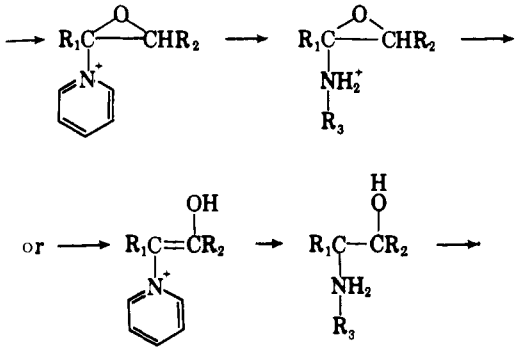
[a] Literature value is 78–79°; R. E. Lutz, *et al.*, *J. Org. Chem.*, **12**, 617 (1947). [b] Calcd. for $C_{15}H_{13}Cl_2NO$: C, 61.3; H, 4.42. Found: C, 60.8; H, 4.11. [c] Literature value is 45–46°; R. E. Lutz, note *a*. [d] Literature value is 84–84.5°; R. E. Lutz, note *a*. [e] Calcd. for $C_{15}H_{13}Br_2NO$: C, 46.8; H, 3.64. Found: C, 47.1; H, 3.36. [f] Literature value is 98.9°; B. L. Zenitz and W. H. Hartung, *J. Org. Chem.*, **11**, 444 (1946). [g] Literature value is 198–199°, 83–88%; note *f*. [h] Literature value is 45–46°, 73%, note *f*. [i] Calcd. for C_9H_8BrClO: C, 46.1; H, 3.08. Found: C, 46.8; H, 3.38. [j] Calcd. for $C_{15}H_{13}Cl_2NO$: N, 4.76; mol. wt., 294.1. Found: N, 5.06; mol. wt., 293. [k] Calcd. for $C_9H_8ClNO_2$: C, 54.8; H, 4.05; N, 7.08; mol. wt., 197.7. Found: C, 54.2; H, 4.09; N, 6.82; mol. wt., 201. [l] Calcd. for $C_9H_8Br_2ClNO_2$: mol. wt., 357.46. Found: mol. wt., 357. [m] Calcd. for $C_{15}H_{13}Cl_2NO$: Cl, 24.10; N, 4.76; mol. wt., 294.2. Found: Cl, 24.07; N, 4.72; mol. wt., 294. [n] Calcd. for $C_9H_8BrNO_2$: C, 44.6; H, 3.30; N, 5.79; mol. wt., 242.3. Found: C, 44.3; H, 3.05; N, 5.89; mol. wt., 242. [o] Calcd. for $C_{15}H_{13}Br_2NO$: Br, 41.72; N, 3.66; mol. wt., 383.1. Found: Br, 41.7; N, 3.53; mol. wt., 382. [p] Calcd. for $C_9H_8ClNO_2$: N, 7.08; mol. wt., 197.73. Found: N, 6.04; mol. wt., 198. [q] 2,4-Dinitrophenylhydrazone, m.p. 104.5–106.5° (calcd. for $C_{15}H_{13}ClN_4O_4$: C, 51.7; H, 3.73. Found: C, 53.2; H, 4.04). Semicarbazone, m.p. 142–144° (calcd. for $C_{10}H_{12}ClN_3O$: C, 53.2; H, 5.32. Found: C, 54.0; H, 5.38). [r] Calcd. for $C_{15}H_{13}Cl_2NO$: N, 4.76; mol. wt., 294.19. Found: N, 4.82; mol. wt., 293. [s] Literature value is 84.5–85.5°; W. S. Ide and J. S. Buck, *Org. Reactions*, **4**, Chapter 5 (1948). [t] Calcd. for $C_{21}H_{17}Cl_2NO_2$: C, 65.3; H, 4.41; Cl, 18.4; N, 3.63. Found: C, 66.1; H, 4.23; Cl, 19.5; N, 3.52. [u] Calcd. for $C_{21}H_{17}Cl_2NO_2$: Cl, 18.4. Found: Cl, 18.8. Calcd. for $C_{21}H_{17}Br_2NO_2$: C, 53.1; H, 3.58; Br, 33.7; N, 2.95. Found: C, 52.6; H, 3.39; Br, 33.2; N, 2.96.

were unable to convert the bis-*meta* analog of IIa with γ-picoline hydrobromide. Presumably conjugation of the carbonyl group with a methoxy substituent is an important factor since the halogen-free analog of Ic is irreversibly converted to the rearranged product.[11] We therefore prepared Ic and Id and found that they could be rearranged with γ-picoline hydrobromide.

Compounds Ic and Id were rearranged competitively using γ-picoline hydrobromide in ethylene glycol. After removal of the solvent and catalyst, we attempted to resolve the mixture using countercurrent extraction. One hundred sixty transfers with a cyclohexene–nitromethane solvent system failed to give the desired separation. However, mass spectrographic analysis of the reaction mixture clearly indicated the presence of fragments which contained chlorine and bromine in the same fragment, thus demonstrating that the rearrangement of α-anilinoketones involves *intramolecular* migration of oxygen and *intermolecular* migration of the nitrogen function according to the mechanism



For reactions catalyzed by tertiary amine salts we propose that the following species may be involved at intermediate stages of the reaction.



Experimental

Syntheses of Compounds.—Since many of the compounds involved in this study were synthesized by common methods, their properties are reported in tabular form. The compounds are arranged in groups representing successive stages of synthesis. Analytical data are included in the footnotes to the table. Infrared spectra are consistent in all cases with structures assigned.

The compounds in Table I were synthesized according to the generalized reaction conditions listed in Table II.

The structures of new compounds were based on synthesis path, infrared and ultraviolet spectra, and chemical analyses. In some cases derivatives were prepared and similarly characterized. The aminoketones were also cleaved and the products identified to establish the isomeric structure relationships.

TABLE II

		Reference
4	$2.7C_6H_6Br + 2.7EtCOCl + 3.0AlCl_3 \xrightarrow[CS_2\ 3\ hr.]{100\ ml.}$	a
7	$0.7C_6H_6COEt + 2\ lb.\ 90\%\ fuming\ HNO_3 \longrightarrow$	b
8	$0.06ArNO_2 + H_2 \xrightarrow[200\ ml.\ 95\%\ EtOH]{Pd\text{-}charcoal}$	b
9	$0.23ArNH_2 + 0.24NaNO_2 \xrightarrow[HCl]{Cu_2Cl_2}$	b
12, 16, 20	$0.3ArCHO + 0.3EtNO_2 + 0.2NH_4OAc \xrightarrow[HOAc]{150\ ml.}$	c
13, 17, 21	$0.5ArC{\equiv}C{-}C + Fe\ powder \xrightarrow[NO_2]{conc.\ HCl}$	c
2, 5, 10, 14, 18, 22	$0.23ArCOR + 0.23Br_2 \xrightarrow[HOAc]{180\ ml.}$	d
3, 6, 11, 15, 19, 23	$1.0RCOCHBrR' + 0.75ArNH_2 + 1.2NaHCO_3 \xrightarrow[EtOH]{N_2,\ 1200\ ml.}$	e
24, 27	$ArCHO + Ar'CHO + 0.37KCN \xrightarrow[80\ ml.\ H_2O]{175\ ml.,\ 95\%\ EtOH}$	f
25, 28	$0.1Ar'CHOHCOAr + 0.12ArNH_2 \xrightarrow[130\ ml.\ C_6H_5Me]{1\ g.\ P_2O_5}$	

[a] R. E. Lutz, *et al.*, *J. Org. Chem.*, **12**, 617 (1947). [b] B. L. Zenitz and W. H. Hartung, *ibid.*, **11**, 444 (1946). [c] Z. Horii, J. Touji, and T. Inoi, *Yakugaku Zasshi*, **77**, 252 (1957) [*Chem. Abstr.*, **51**, 8672 (1957)]. [d] A. I. Vogel, "Practical Organic Chemistry," Longmans, Green, and Co., New York, N. Y., 1948, pp. 835–836. [e] P. L. Julian, *et al.*, *J. Am. Chem. Soc.*, **67**, 1208 (1945). [f] W. S. Ide and J. S. Buck, *Org. Reactions*, **4**, Chapter 5 (1948). [g] R. E. Lutz and J. W. Baker, *J. Org. Chem.*, **21**, 49 (1956).

Hydrogen bromide (purified by passage over hot copper turnings) was bubbled into an ether solution of the amine to prepare the hydrobromides used as catalysts.

Rearrangement of 2-(4-Chloroanilino)-1-(4-chlorophenyl)-1-propanone.—Five sets of conditions were used in attempts to rearrange this ketone. The solvent (50 ml.) was refluxed under a flowing nitrogen atmosphere to remove dissolved oxygen. To the cooled solvent was added 5.88 g. (0.02 mole) of the yellow anilinoketone and 0.02 mole of the catalyst. No evidence of rearrangement was found (change from yellow to colorless, followed by visible spectra of aliquot samples) with pyridine hydrobromide in 95% ethanol under reflux for 24 hr. or in pyridine under reflux for 70 hr. γ-Picoline hydrobromide gave no rearrangement in 95% ethanol under reflux for 180 hr.

Rearrangement was successful using 95% ethanol and *p*-chloroaniline hydrobromide under reflux for 25 hr. A small amount of the colorless rearrangement product was isolated and recrystallized from 95% ethanol; m.p. 78.5–79.5°.

Rearrangement of 2-(4-Dichloroanilino)-1-(4-chlorophenyl)-2-(4-methoxyphenyl)-1-ethanone.—To 1.00 g. (0.00259 mole) of the anilinoketone dissolved in 25 ml. of solvent was added 0.45 g. (0.00259 mole) of γ-picoline hydrobromide. The solution was refluxed under a nitrogen atmosphere to prevent oxidative degradation of the anilinoketone. The rearranged product was obtained in 95% ethanol under reflux for 7 days and in ethylene glycol refluxed for 14 hr. No rearrangement was observed in refluxing mesitylene. The rearrangement product was purified by recrystallization from 95% ethanol to give yellow crystals, m.p. 127–127.2°. The infrared and ultraviolet spectra and chemical analysis (18.8% chlorine) were consistent with the assigned structure.

Attempted Rearrangements.—1-(4-Chloroanilino)-1-(4-chlorophenyl)-2-propanone, 1-(4-bromoanilino)-4-bromophenyl)-2-propanone, and 1-(3-chloroanilino)-1-(3-chlorophenyl)-2-propanone failed to rearrange using γ-picoline hydrobromide in refluxing ethanol or glycol.

Competitive Rearrangement of 2-(4-Bromoanilino)-1-(4-bromophenyl)-2-(4-methoxyphenyl)-1-ethanone and 2-(4-Chloroanilino)-1-(4-chlorophenyl)-2-(4-methoxyphenyl)-1-ethanone —A mixture of 1.0 g. (0.002 mole) of dibromo-α-anilinoketone, 0.812 g. (0.002 mole) of dichloro-α-anilinoketone, and 0.367 g. (0.002 mole) of γ-picoline hydrobromide in 50 ml. of ethylene glycol under an atmosphere of purified nitrogen was heated in a bromobenzene vapor bath (*ca.* 148° at 650 mm.) for 2 hr. and then slowly cooled to room temperature. The reaction mixture was

further cooled in an ice bath to complete crystallization. The crystals were collected on a Büchner funnel, triturated with a 3:1 water–ethanol solution, and vacuum dried.

The product from one run was carried through 160 transfers in a 100-tube Craig countercurrent extractor using cyclohexene saturated with nitromethane as the upper moving phase and nitromethane saturated with cyclohexene as the lower stationary phase. The solvent system has been shown to have reasonable distribution coefficients for the desired separation but apparently caused side reactions which destroyed the identity of the anilinoketones.

The product from a second run was submitted for mass spectral analysis.

Mass Spectrometric Analysis.[12]—The mass spectra were determined for separate samples of the two pure dihalo-α-anilinoketones, a mechanical mixture of the two, and the product isolated from the competitive rearrangement. In all cases the parent peaks differed from the expected values by the mass of water (not surprising in view of the synthetic conversion of α-anilinoketones to indoles).

The mass spectrum of the dibromo-α-anilinoketone shows ion currents at 455, 457, 459 (loss of water); 304, 306 (loss of the *p*-bromoanilino group); 171, 173 (the *p*-bromoanilino group); 440, 442, 444 (loss of the methoxyl group from the ketone or the methyl group from the indole); 155, 157 (the bromophenyl group); 135 (loss of both the *p*-bromobenzoyl group and the the bromophenyl group); and 121 (the *p*-methoxybenzal group). Peak heights and positions corresponded to expected relationships for relative isotope abundances.

The spectrum of the dichloro-α-anilinoketone was exactly analogous.

The spectrum for the mechanical mixture was an exact superposition of the spectra for the separate components.

The spectrum from the competitive rearrangement product shows all of the ion currents found in the spectra of the pure dibromo- and dichloro-α-anilinoketones and, in addition, ion currents corresponding to fragments containing both bromine and chlorine atoms in the same fragment.

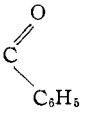
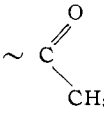
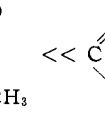
(12) The mass spectrometric analyses were run by Dr. Don Schissler of Shell Development Laboratories, Emeryville, Calif.

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, UNIVERSITY OF CALIFORNIA, DAVIS, CALIF.]

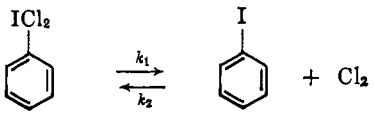
Ester, Ether, and Carbonyl Functions as *ortho* Participants in the Dissociation of Iodobenzene Dichloride

BY L. J. ANDREWS, L. J. SPEARS, AND R. M. KEEFER

RECEIVED SEPTEMBER 7, 1963

The rates of dissociation of a series of *o*- and *p*-isomers of iodobenzene dichloride ($XC_6H_4ICl_2$) in acetic acid have been determined (X = CH_2COCH_3, $CH_2COC_6H_5$, $COCH_3$, COC_6H_5, and CH_2COOCH_3). The capacities of various *o*-substituents to promote the dissociation reaction by electron release to iodine in the transition state varies in the order $CH_2OC_6H_5 < CH_2COOCH_3 < CH_2OCH_3 <$  $\sim$  $<<$  The mechanistic implications of these observations are discussed.

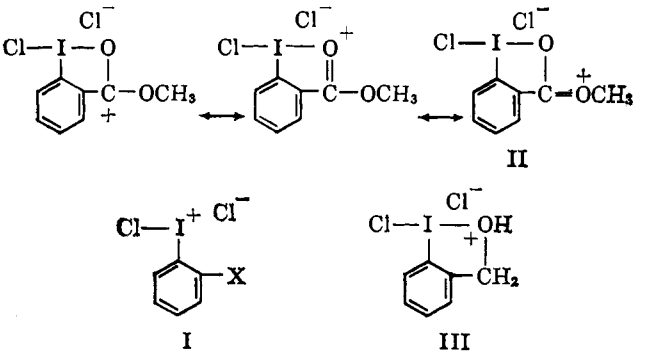
The rate of dissociation of iodobenzene dichloride (eq. 1) in acetic acid ordinarily is not strongly influenced by the introduction of ring substituents.[1] The k_1 values



(1)

for isomeric *o*- and *p*-substituted dichlorides are generally about the same. Certain of the *o*-isomers—in particular those in which the substituents can function as nucleophiles—are, however, much more reactive than the corresponding *p*-derivatives.[2,3] The carbomethoxy- and hydroxymethyliodobenzene dichlorides, among others, fall into this exceptional reactivity class. Presumably when the $-COOCH_3$ and $-CH_2OH$ groups are located *ortho* to the reaction center, they contribute to the transition state (which is considered to be polarized as indicated in formula I) by release of electrons to the iodine atom (II, III).

The capacities of several more *o*-substituents to participate in the iodobenzene dichloride dissociation reaction in acetic acid have now been investigated. The relative effectiveness of ether and of carbonyl oxygen, as compared with the previously investigated ester oxygen, in acting a scenters of nucleophilicity has been assessed through a comparative rate study of the *o*- and *p*-CH_2OCH_3, $-CH_2OC_6H_5$, $-COCH_3$, and $-COC_6H_5$ iodobenzene dichloride derivatives. To determine whether a five- or six-ring cycle provides for greater transition state stabilization by the $-COOCH_3$ group, the relative reactivities of the *o*- and *p*-CH_2COOCH_3 substituted dichlorides have been compared



I II III

with those of the *o*- and *p*-carbomethoxy substituted dichlorides.

Experimental

The Iodo Compounds. (a) **Methyl *o*-Iodophenylacetate.**—A sample of *o*-iodobenzyl alcohol was prepared by reduction of *o*-iodobenzoyl chloride (Eastman Organic Chemicals) with lithium aluminum hydride.[4] The alcohol was converted to the corresponding bromide.[5] This was converted, *via* the cyanide, to *o*-iodophenylacetic acid (m.p. 112–114°) by the procedure of Rapson and Shuttleworth.[6] A mixture of 18 g. of the acid, 13 g. of methanol, 250 ml. of methylene chloride, and 7 ml. of concentrated sulfuric acid was refluxed for 24 hr. The ester was isolated from the crude product by standard procedures in 8.6 g. (45%) yield, b.p. 138° (5 mm.), lit.[7] b.p. 114° (1 mm.).

(b) **Methyl *p*-Iodophenylacetate.**—A sample of *p*-iodophenylacetic acid was prepared by reaction of the diazonium salt of *p*-aminophenylacetic acid (Eastman Organic Chemicals) with potassium iodide.[8] A 10.7-g. sample of the acid was refluxed with thionyl chloride for 3 hr. The excess thionyl chloride was

(1) R. M. Keefer and L. J. Andrews, *J. Am. Chem. Soc.*, **80**, 277 (1958).
(2) L. J. Andrews and R. M. Keefer, *ibid.*, **81**, 4218 (1959).
(3) R. M. Keefer and L. J. Andrews, *ibid.*, **81**, 5329 (1959).
(4) B. O. Field and J. Grundy, *J. Chem. Soc.*, 983 (1927).
(5) W. Raum, *Ber.*, **27**, 3233 (1894).
(6) W. S. Rapson and R. G. Shuttleworth, *J. Chem. Soc.*, 489 (1941).
(7) J. E. Leffler and A. F. Wilson, *J. Org. Chem.*, **25**, 424 (1960).
(8) A. I. Vogel, "A Textbook of Practical Organic Chemistry," Longmans, Green and Co., London, 1956, p. 599.