the influence of multiple alkoxy substitution at a tetrahedral carbon[25] and direct conjugation phenomena between methoxy and nitro substituents.

We may now ask what connection, if any, can be established between the factors affecting the adduct formation in six-membered rings and that in the thiophene system under investigation. In the latter case we have observed a comparable rate of formation and a much higher stability constant relative to the 2,4,6-trinitroanisole system. A comparison in terms of geometrical parameters is not strictly correct since too many changes are involved altogether on passing from one system to another. An important point to keep in mind is that the observed overall stability constant for the five-membered ring system depends not only on the stability of the resulting adduct but also on that of the starting heteroaromatic system. It is likely that the energy content of the thiophene system is higher than that of 2,4,6-trinitroanisole. It is of interest to note that calculations of the localization energy at the 2 position of thiophene,[26] for electrophilic as well as nucleophilic reactions, indicate that the formation of a σ complex at this position is clearly favored with respect to benzene.

There are, however, two points of structural comparison which must be made despite the difficulties of assessment just mentioned. The first point concerns the steric situation of the nitro groups in the thiophene derivative. Because of the lower steric compression between vicinal groups in the five-membered ring and the presence of only one flanking nitro group, the steric factor, *i.e.*, reduced steric inhibition of resonance, cannot account for the stability of the complex. The second point concerns the *relative* change in geometry of the two systems under comparison.

The C(2)–C(1)–C(6) angle in trinitroanisole is almost 120°, while the S–C(2)–C(3) angle of the thiophene derivative should be near to 111.5°.[27] When the C(1) atom in the former compound forms a new bond with methoxide ion, the C(2)–C(1)–C(6) angle in the adduct is forced to a value close to that of a tetrahedral carbon atom (109.5°), and, therefore, a certain amount of strain affects the six-membered ring. As to the adduct of the thiophene derivative, a tetrahedral value can also be expected for the S–C(2)–C(3) angle, but this is much closer to that of the original substrate. It is then to be expected that the formation of the adduct involves less bond strain in the five-membered than in the six-membered ring system.

Although the adduct from 2-methoxy-3,5-dinitrothiophene is thermodynamically stable, it is easily destroyed by a strong excess of nucleophilic reagents (see Experimental Section). Also, in agreement with other workers,[11] we have found that the yield in the methoxy dechlorination of 2-methoxy-3,5-dinitrothiophene is very low. These facts could be reconciled with the generally accepted two-step mechanism of aromatic substitution provided that the intermediate σ complex having a Meisenheimer-type structure in some cases is diverted to a decomposition path other than the one leading to the conventional substitution product.

Registry No.—MDNT, 27357-00-2; methoxide ion, 3315-60-4; 2,2-dimethoxy-3,5-dinitrothiacyclopentenate ion, 29152-91-8.

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Substituent Effects in the Reaction of Sodium 4-Nitrophenoxide with 2-Bromoacetanilides

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The kinetics of the reaction of sodium 4-nitrophenoxide with ten 3′- and 4′-substituted 2-bromoacetanilides in 2-methoxyethanol solvent have been examined at 45.3, 55.3, and 65.3°. Second-order kinetics were found, and the rate constants were fit to a Hammett-type equation using van Bekkum, Verkade, and Wepster normal σ values to yield a ρ value of $+0.65 \pm 0.02$, independent of temperature. The amide link is transmitting substituent effects relatively efficiently in this process. Apparently normal activation parameters were encountered.

The transmission of activation effects through acyl links in compounds of the type XCH$_n$COZY from Y to a reactive site X adjacent to the carbonyl group has been little studied; Z is taken to be an atom with an unshared electron pair, nitrogen in the present case. A considerable body of information relates the effect of a change at X with reactivity or equilibria at the carbonyl group or at atom Z; examples are of the pK_a's of substituted amino acids[3] and phenylacetic acids,[4] the infrared frequencies of substituted anilides,[5] the hydrolysis reactions of phenylacetates,[6] as well as many other reactions which could be cited. On the other hand, when this work was begun virtually no work had been reported which dealt with transmission of effects from Y to X; for example, no measurements of pK_B of substituted glycine anilides have been reported. It is clear that

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transmission of activation effects through amide, ester, and thio ester chains to the carbon atom adjacent to the carbonyl group has important biochemical implications.

A Hammett-type correlation is used in our studies. A suitably substituted group of compounds XCH_n-COZAr is prepared and the reaction at X is studied kinetically (or an equilibrium constant could be determined); if a Hammett type correlation is obtained, ρ is taken as a measure of the transmission efficiency.[7-9] We have studied the elimination of hydrogen bromide from N-alkyl- (or aryl-) N'-(β-bromopropionyl)ureas[10a] and the addition of ethanol to substituted acrylanilides catalyzed by sodium hydroxide;[10b] in both these examples the transmission efficiency of the amide group appeared to be high. The ^{19}F nmr of trifluoroacetanilides were found to correlate with σ^+, but the σ value was found to be low (0.06).[11] Professor Menger has measured the pK_a's of some anilides of *p*-hydroxybenzoic acid and found a low ρ value (0.06).[12] The present work extends the previous studies to the displacement reaction of sodium 4-nitrophenoxide on 2-bromoacetanilides in what seems to be a simple S_N2-type reaction.

Ten variously substituted 2-bromoacetanilides were prepared by reaction of the aniline with bromoacetyl bromide. The products had the expected infrared and nmr spectra; proper analyses were obtained for new compounds. After some experimentation the reaction of the bromoacetanilides with sodium 4-nitrophenoxide in 2-methoxyethanol was chosen for kinetic study (eq 1).

$$BrCH_2CONHAr + 4\text{-}O_2NC_6H_4O^- \longrightarrow 4\text{-}O_2NC_6H_4OCH_2CONHAr + Br^- \quad (1)$$

The reaction proceeded at a reasonable rate at accessible temperatures and could be followed conveniently by monitoring the nitrophenoxide band at 405 nm; neither the bromoanilides nor the product nitrophenoxyacetanilides absorbed appreciably at this wavelength with the exception of 3'-nitro-2-bromoacetanilide. A rearrangement reaction of the product ether to 4-nitrophenylarylamines did provide a potential interference problem, but the rearrangement was not encountered in appreciable amounts in kinetic runs. The product ethers were synthesized by reaction of the nitrophenoxide with bromoacetanilides at slightly higher concentrations than those used in the kinetic runs. Microanalyses, infrared spectra, and nmr spectra were consistent with the expected products.

The synthetic scale reactions leading to the product ethers were subjected to thin layer chromatography periodically to detect the presence of additional components. In most instances only starting materials and final products were detectable. In a few preparations an additional yellow component was noted toward the end of the reaction; this component was shown to be 4-nitrodiphenylamine in the reaction of bromoacetanilide with 4-nitrophenoxide by comparison of the

$$O_2NC_6H_4OCH_2CONHAr \longrightarrow O_2NC_6H_4NHAr + \text{“}OCH_2CO\text{”}$$

isolated component with an authentic sample using melting point, infrared spectra, and nmr spectra. The yellow product from 2,4'-dibromoacetanilide and 4-nitrophenoxide was shown to be 4-nitro-4'-bromodiphenylamine by melting point, nmr spectra, and infrared spectra. The rearrangement of this class of compounds was reported in low yield by Smiles[13] using hot aqueous sodium hydroxide with glycolic acid as the other product. In our hands reaction of the 2-(4-nitrophenoxy)-acetanilides with bases such as carbonate in aqueous methanol led to 50-70% yields of the diphenylamine upon reflux for a few hours. No effort was made to achieve higher yields, though the reaction seems to be an easy entry into the diphenylamine series.

The kinetics of the reactions were followed under pseudo-first-order conditions; the nitrophenoxide (typically 10^{-4} *M*) concentration was followed in the presence of excess bromoacetanilide (typically 10^{-2}-10^{-3} *M*). The reactions gave good first-order plots to 80-90% completion. The data were analyzed by least-squares analysis. The average deviation from the best straight line was 0.8-1.1%. Agreement of rate constants between identical runs was within 1-3%. Three runs were made for each reported rate constant at 55.3° using at least two different sets of solutions and two runs were made for each reported rate constant at 45.3 and 65.3°. Reported points are an average of the runs conducted. Carbon dioxide caused some difficulties, and it was necessary to work under a nitrogen atmosphere with anhydrous solvents and reagents. The data supporting the second-order character of the reaction are in Table I. The reaction of 4-nitrophenoxide with 2-bromoacetanilide in methoxyethanol at 55.28 ± 0.04° gave a second-order rate constant of $2.33 \pm 0.04 \times 10^{-3}\ M^{-1}\ sec^{-1}$ for anilide concentrations varying from 2.98 to 8.71×10^{-2} *M* with the initial nitrophenoxide concentration 5.77×10^{-4} *M*.

Table I

Rate of Reaction of *p*-Nitrophenoxide with α-Bromoacetanilide in 2-Methoxyethanol (55.28°)

[RBr],[a] $M \times 10^2$	[ArO⁻],[b] $M \times 10^4$	10^3k_1,[c] min^{-1}	10^3k_2,[c] $M^{-1}\ sec^{-1}$
5.767	5.78	8.34 ± 0.09[d]	2.41
5.767	5.78	8.06 ± 0.06	2.33
5.822	5.77	8.27 ± 0.03	2.37
8.714	5.77	11.95 ± 0.06	2.29
8.714	5.77	12.06 ± 0.08	2.31
2.981	5.77	4.13 ± 0.03	2.31
2.981	5.77	4.09 ± 0.04	2.28
			Av 2.33 ± 0.04

[a] Concentration of α-bromoacetanilide. [b] Concentration of sodium *p*-nitrophenoxide. [c] k_1 is the pseudo-first-order rate constant; k_2 is the second-order rate constant. [d] Error is the average deviation from best straight line for the particular kinetic run. An average of 15 points were used per line.

Each of the compounds studied has an NH which might act as an acid toward the base 4-nitrophenoxide yielding product through an α-lactam intermediate. Rate determinations were carried out in the presence of

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[13] B. T. Tozer and S. Smiles, *J. Chem. Soc.*, 2052 (1938).

Table II

Reaction of Sodium *p*-Nitrophenoxide with Substituted α-Bromoacetanilides in 2-Methoxyethanol

Substituent	Registry no.	10^3k_2, M^{-1} sec^{-1} 45.27°	55.27°	65.25°	σ^n
4-OCH_3	29182-87-4	0.747 ± 0.016[a,b]	1.97 ± 0.03	4.99 ± 0.05	−0.175[c]
4-CH_3	5343-65-7	0.786 ± 0.013	2.03 ± 0.05	5.22 ± 0.04	−0.129
H	5326-87-4	0.884 ± 0.017	2.33 ± 0.04	6.08 ± 0.02	0
4-Cl	5343-64-6	1.41 ± 0.03	3.57 ± 0.02	9.19 ± 0.02	0.238
4-Br	5439-13-4	1.42 ± 0.01	3.71 ± 0.06	9.54 ± 0.06	0.265
4-$CO_2C_2H_5$	29182-92-1	1.78 ± 0.01	4.52 ± 0.02	11.4 ± 0.05	0.385
4-$COCH_3$	29182-93-2	1.98 ± 0.02	5.17 ± 0.05	13.0 ± 0.13	0.502
3-OCH_3	29182-94-3		2.45 ± 0.02		0.076
4-SO_2CH_3	29182-95-4		7.39 ± 0.07		0.686
3-NO_2	29182-96-5		6.38 ± 0.07		0.710
4-H-NCH_3[d]	29182-97-6		3.20 ± 0.01		
ρ[e]		0.66 ± 0.02	0.65 ± 0.03[f]	0.64 ± 0.01	
r		0.995	0.991	0.998	

[a] Errors quoted are average of average deviation from best straight line for individual runs. [b] Initial concentrations except for 4-SO_2CH_3 and 3-NO_2 were [RBr] ~ 5.8×10^{-2} *M*; [ArO^-] ~ 5.8×10^{-4} *M*. For 3-NO_2 and 4-SO_2CH_3, initial concentrations were [RBr] ~ 3×10^{-2} *M*; [ArO^-] ~ 5.8×10^{-4} *M*. [c] Reference 14. [d] Compound is *N*-methyl-α-bromoacetanilide. [e] Computed by the method of Jaffé, ref 8. Errors in ρ are Jaffé's S or $S\rho$. [f] ρ value computed from some substituents as used at 45 and 65° is +0.65 ± 0.02, $r = 0.997$.

2,6-lutidine (at five times the concentration of the 4-nitrophenoxide) using 4′-methyl-2-bromoacetanilide in excess; in the presence of the lutidine the second-order rate constant was 2.13×10^{-3} M^{-1} sec^{-1}; in its absence the rate constant was 2.03×10^{-3} M^{-1} sec^{-1}. The small difference (within the combined experimental error) between the two runs is taken as insignificant. In addition the *N*-methyl derivative of 2-bromoacetanilide was prepared and its rate of reaction compared to that of the NH compound. With essentially identical concentrations of materials the rate constant of the *N*-methyl compound was 3.20×10^{-3} M^{-1} sec^{-1}; that for the NH compound was 2.33×10^{-3} M^{-1} sec^{-1}. Certainly the NH is not required to attain the rates observed. If an α-lactam were an intermediate, its formation could be rate determining, in which case base catalysis should be observed. Alternatively, reaction of the α-lactam with 4-nitrophenoxide could be rate determining, in which case second-order kinetics with the phenoxide should have been observed. In addition, the reaction of the *N*-methyl compound should have been substantially slower than the N–H compound in either case if an α-lactam is required. The NH is probably inactive in the displacement reactions studied.

The rate constants for individual compounds at three temperatures are shown in Table II at 45.3, 55.3, and 65.3°. Ten compounds were measured at 55.3° and seven at the other two temperatures. All compounds were measured at essentially the same concentration except those with 4-CH_3SO_2 and 3-O_2N substituents. These substituents caused a sufficiently fast reaction that the concentrations of the anilides had to be reduced by a factor of about two to be measurable with the techniques used on the other compounds.

The rate constants were fit to variations of the Hammett equation. As was the case with other displacement reactions, the fit to the original Hammett equation was not good with compounds having negative σ substituents. For example, 4-methyl and 4-methoxy have essentially identical rate constants. For this reason we chose to use the "normal" substituent constants of van Bekkum, Verkade, and Wepster;[14] with these substituent constants the ρ value obtained at 55.3° was 0.65 ± 0.03. The correlation coefficient[8] was 0.991. The ρ for 65.3 and 45.3° was 0.64 ± 0.02 and 0.66 ± 0.03, respectively, with the corresponding correlation coefficients 0.998 and 0.995. The difference in correlation coefficients between the 55.3° and other runs is due almost exclusively to the inclusion of values for 4-CH_3SO_2- and 3-O_2N-bearing compounds at this temperature; these compounds deviate from the best straight line (in opposite directions) far more than any other compounds.

It is clear that the substituent effect from the aromatic ring is being transmitted to the reaction site, presumably through the amide bonds. How efficient the transmission is calculated to be depends upon the models chosen for comparison. The reaction of benzyl chloride with potassium iodide in acetone at 20° has a ρ of +0.786 (correlation coefficient 0.86).[8] The reaction of benzyl chloride with trimethylamine in benzene has dramatic curvature[15] and did not appear to be a useful comparison point. Alternatively, the reactions of phenacyl halides might be used as comparison data. Essentially two classes of ρ values for phenacyl halides with nucleophiles exist. With nucleophiles such as methoxide[16] and cyanide[17] high ρ values (2.82 for methoxide in methanol at 25°) are obtained. With methoxide it has proven possible to isolate epoxide compounds, suggesting substantial carbonyl participation. With other less basic nucleophiles substantially lower ρ values have been observed in reactions with phenacyl halides. For example, the reaction of aniline with substituted phenacyl halides in 90% ethanol at 30.5° shows that a ρ value of 0.597 (correlation coefficient 0.98)[18] is found. This and the rate constants immediately following have been recalculated using σ^n values;[14] better agreement is noted than with standard σ values. Phenacyl bromide with pyridine in acetone at 20° shows a ρ value of 0.54.[19] Triphenylphosphine with phenacyl

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bromides in nitromethane at 34.9° has a ρ value of 0.45.[20] The reaction of 2,6-dimethyl-4-thiopyrone with phenacyl in benzene at 25.4° has a ρ of 0.95.[21] If one assumes that the values for benzyl chloride with potassium iodide and the lower range of ρ values (0.3–0.9) for phenacyl halide displacement reactions are valid comparison points, then the 0.65 ρ value reported here indicates reasonably efficient transmission of activation effects.

The energy parameters of activation for each compound are shown in Table III. The entropy of activation values reported are apparently normal for reactions of an ion with a neutral molecule.[22] The absence of an appreciable temperature coefficient for ρ over the temperature range studied is worth noting; the ρ values at 65, 55, and 45° were identical within experimental error.

TABLE III

ACTIVATION PARAMETERS FOR REACTION OF *p*-NITROPHENOXIDE WITH SUBSTITUTED α-BROMOACETANILIDES

Substituent	ΔE_a, kcal/mol	$\Delta S^{\ddagger}$, eu
4-OCH_3	20.4	−11.0[a]
4-CH_3	20.3	−11.1
H	20.7	−9.7
4-Cl	20.1	−10.6
4-Br	20.5	−9.5
4-$CO_2C_2H_5$	19.9	−10.7
4-$COCH_3$	20.2	−9.6

[a] Entropy of activation calculated at 55° from the equation $\Delta S^{\ddagger} = 4.577 \log A - 60.716$.

It is interesting that the two kinetic measurements reported have given appreciable transmission of substituent effects through the amide bond; ρ for the addition of ethanol to acrylanilides[11] was +1.77, and ρ for the displacement reactions reported here was +0.65. On the other hand the measurement of p*K* values by Donohue, Scott, and Menger[13] and the ^{19}F chemical shifts for trifluoroacetanilides[12] both gave values of less than 0.1. The data thus far reported indicate a transition state effect rather than major contributions from bround state differences, but more must be done to substantiate this possibility.

The mechanism of transmission is not established by work to date. A predominant inductive effect appears untenable because of the σ^n dependence which was observed, but either a resonance-type effect or a more generalized polar effect (polarizability) could account for the effects found to date.

Experimental Section

Bromoacetyl bromide was purchased from Aldrich Chemical Co. 4-Methylthioaniline was purchased from Matheson Coleman and Bell. Sodium 4-nitrophenoxide dihydrate obtained from Eastman Organic Chemicals was dried in an Abderhalden-type vacuum drying apparatus. 2-Methoxyethanol obtained from Matheson Coleman and Bell was stored over Linde Molecular Sieve 5A and anhydrous sodium carbonate and then distilled twice under a nitrogen atmosphere. The distillate boiling between 121.0 and 122.0° uncorr was collected.

A Perkin-Elmer Model 137 sodium chloride spectrophotometer was used to obtain all infrared spectra. A Varian Associates Model A60 analytical nmr spectrometer was used to obtain nmr spectra. A Thomas-Hoover capillary melting point apparatus was used to determine melting points; melting points were corrected.

Preparation of 2-Bromoacetanilide and Its Derivatives.—A solution of 0.10 mol of aniline in 100 ml of benzene was added to a stirred solution of 0.05 mol of bromoacetyl bromide in 200 ml of benzene at room temperature. A mild exothermic reaction occurred and aniline hydrobromide precipitated out of the reaction mixture. The reaction mixture was stirred for 30 min, and the benzene was removed using a rotary evaporator. The residue was dissolved in 95% ethanol, and the solution was acidified by the addition of 3 *N* sulfuric acid.[23a] Addition of water to the solution induced crystallization. The product[23b] was collected by suction filtration and washed with water. The filtrate possessed lachrymatory properties. The product was recrystallized from ethanol–water using decolorizing carbon. The yield of 2-bromoacetanilide obtained after two crystallizations from benzene was 43%.

The following derivatives of 2-bromoacetanilide were prepared using the above procedure: unsubstituted, mp 134.0–135.0° (reported 130–131°,[24] 129–130°[25]); 3′-OCH_3, mp 98.5–99.5° (unreported[26]); 4′-OCH_3, mp 130.5–131.5° (unreported[26]); N-CH_3, mp 46.5–47.5° (reported 46.8–47.3°,[27] 69°[28]); 4′-CH_3, mp 165.5–167° (reported 164°[29]); 4′-chloro, mp 155.5–156.5° (reported 153–155°,[30] 161°[31]); and 4′-bromo, mp 169–170° (reported 168–169°[30]). The following derivatives of 2-bromoacetanilide were prepared as above except that the acetone was used for the reaction solvent: 4′-$CO_2C_2H_5$, mp 121.0–121.5° (unreported[26]); 4′-$COCH_3$, mp 158–159° (reported 157°[32]); 4′-SO_2CH_3, mp 185.5–186.5° (reported 134°[33]), a correct analysis was obtained for this compound,[26] and 3′-NO_2, mp 124.5–125.5° (unreported[24]). All of the anilines required for the syntheses, except the 4-SO_2CH_3, were commercially available.

Conversion of 4-Methylthioaniline to 4-Methylsulfonylaniline.—4-Methylthioaniline was acetylated quantitatively with acetic anhydride using the procedure described by Fieser[34] for the acetylation of aniline. The melting point was 128–129.5°, lit. mp 128°[35] and 130.5°.[36]

4′-Methylthioacetanilide was treated with 30% H_2O_2 according to the procedure described by Yagupol'skii and Marenets,[37] with the only modifications that the quantity of each reagent used was increased fivefold and that the time of reaction was reduced to 5–10 min. The reaction was monitored by thin layer chromatography. The product isolated using the original 2-hr heating period appeared as two components on a thin layer chromatogram, and the nmr spectrum of the product mixture indicated that 4′-methylsulfonylacetanilide composed only about 10% of the mixture. The major product was isolated as canary yellow needles, mp 139–140.5°; infrared and nmr spectra were consistent with its identification as 4-nitrophenyl methyl sulfone (lit. mp 141°[38] and 142.5°[39]). The desired product crystallized

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[23] (a) The use of concentrated HCl in the preparation of 2,4′-dibromoacetanilide caused a significant conversion of the desired 2-bromo product into the 2-chloro product detected by nmr spectra in the products. (b) When 3-nitro- and 4-carboethoxyaniline were used, the corresponding aniline salts were isolated along with the desired 2-bromoacetanilide product. The mixed product was extracted with ether to free the desired product from the aniline salt. The presence of the aniline salt could be recognized by examining the infrared spectrum of the product.

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[35] O. Hinsberg, *Chem. Ber.*, **39**, 2437 (1906).

[36] L. Gattermann, *Justus Liebigs Ann. Chem.*, **393**, 215 (1912).

[37] L. M. Yagupol'skii and M. S. Marents, *Zh. Obshch. Khim.*, **27**, 1935 (1957); *Chem. Abstr.*, **52**, 2781 (1958).

[38] T. Zinke and S. Lenhardt, *Justus Liebigs Ann. Chem.*, **400**, 2 (1913).

[39] W. R. Waldron and E. E. Reid, *J. Amer. Chem. Soc.*, **45**, 2402 (1923).

from an ethanol–water mixture in 60% yield, mp 187.5–189° (lit. mp 183°[40] and 185–186°[37]). The nmr and infrared spectra were consistent with this structure.

4′-Methylsulfonylacetanilide was hydrolyzed to 4-methylsulfonylaniline with dilute HCl. A 78% yield was obtained after crystallization from chloroform, mp 139–140.5° (lit. 133°[41] and 134–135°[37]). Infrared and nmr spectra were consistent with the postulated structure and different from the major product in the paragraph above.

Preparation of Substituted 2-(4-Nitrophenoxy)acetanilides.—A reaction mixture of 500 mg of substituted 2-bromoacetanilide, a 10% mole excess of anhydrous sodium 4-nitrophenoxide, and 10 ml of anhydrous 2-methoxyethanol was heated at 55°. The progress of the reaction was monitored by thin layer chromatography on silica gel with chloroform or chloroform with 2–5% ethanol as the eluent. The reaction time varied from 1 to 30 hr depending upon the 2-bromoacetanilide derivative used. Approximately 200 ml of water was added to the reaction mixture to precipitate the product. The ether was collected by vacuum filtration, washed with water, and air-dried. Thin layer chromatography on silica gel plates indicated that only one product was formed in the faster reactions, but that in the slower reactions the product contained about 1% of a yellow impurity, which was identified as a substituted 4-nitrodiphenylamine.

The product was purified by dissolving it in acetone, filtering off any solid materials, then adding 2–3 vol of benzene, and distilling off the acetone. If the product did not crystallize from the benzene solution, the product was crystallized from a mixture of benzene and cyclohexane. The yellow impurity was generally eliminated as a contaminant by crystallization. The yellow impurity could be eliminated easily by column chromatography on silica gel with benzene elution. The yellow impurity moved rapidly through the column in contrast to the slow-moving product.

The following ring-substituted 2-(4-nitrophenoxy)acetanilides were prepared: unsubstituted, mp 170.5–171.5° (reported 170–171,[42] 170,[43] 172°[26]); 3′-NO_2, mp 180.5–181.5° (reported 177–180°[44]); 4′-OCH_3, mp 179–180° (unreported[26]); 3′-OCH_3, mp 121–122° (unreported[26]); 4′-CH_3, mp 128–128.5° (unreported[26]); 4′-Cl, mp 181–181.5° (unreported[26]); 4′-Br, mp 167–168° (unreported[26]); 4′-$CO_2C_2H_5$, mp 189.5–190.5° (unreported[26]); 4′-$COCH_3$, mp 193.5–194.5° (unreported[26]); 4′-SO_2CH_3, mp 202.5–203.5° (unreported[26]); and N-CH_3, 116.5–117.5° (unreported[26]). Nmr and infrared spectra were obtained for all compounds and were consistent with the postulated structures.

Conversion of 2-Bromoacetanilide to 2-(4-Nitrophenoxy)-acetanilide and 4-Nitrodiphenylamine.—A mixture of 1.00 g (4.67 mmol) of 2-bromoacetanilide, 0.83 g (5.15 mmol) of sodium 4-nitrophenoxide, and 20 ml of 2-methoxyethanol was heated at 55–60° for 64 hr. The progress of the reaction was followed by thin layer chromatography using silica gel adsorbent and chloroform as the eluent. The solvent was removed from the reaction mixture with a Büchi rotary evaporator, and the residue was extracted twice with 200-ml portions of hot benzene. The residue obtained upon removing the benzene with a rotary evaporator was chromatographed on a silica gel column using benzene as the eluent. A yellow compound moved rapidly through the column and yielded 15 mg of 4-nitrodiphenylamine after crystallization from cyclohexane. The assignment of structure was based upon comparison of spectra and a mixture melting point with a commercially available authentic sample.

Sodium carbonate was added to a 1:1 water–ethanol solution of 2-(4-nitrophenoxy)acetanilide, and the mixture was refluxed until thin layer chromatography on silica gel coated microscope slides with chloroform as the eluent indicated complete consumption of the 2-(4-nitrophenoxy)acetanilide present. The yield of 4-nitrodiphenylamine, mp and mmp 135–136°, was 40%. In similar fashion were prepared 4-nitro-4′-bromodiphenylamine, mp 161.5–162.5°, and 4-nitro-4′-chlorodiphenylamine, mp 180–181°.

Determination of the Rate Constants.—The reaction flask was a single-neck, flat-bottom boiling flask modified by the addition of a 8 × 90 mm side tube. The side tube bore a rubber septum. The reaction flask was equipped with a cold finger condenser by means of a straight type adapter with a hose connector to serve as a nitrogen inlet.

Stock solutions of anhydrous sodium 4-nitrophenoxide and 2-bromoacetanilide in dry 2-methoxyethanol were prepared in 50-ml volumetric flasks at room temperature and were stored in a cool, dark cabinet. The quantities of sodium 4-nitrophenoxide and 2-bromoacetanilide used were known by direct weighing.

The 2-bromoacetanilide stock solution (20 ml) was syringed into the reaction flask equipped with a magnetic stirrer and a static atmosphere of nitrogen. The solution was thermally equilibrated with the water bath for approximately 20 min, and then 0.5–1 ml of the sodium 4-nitrophenoxide stock solution was syringed into the reaction flask. The volumes were accurate within 2%.

The initial sample was removed immediately after addition of the sodium 4-nitrophenoxide solution and subsequent samples were taken at constant time intervals of 7.5–30.0 min, depending upon the rate of the reaction. The reaction time, during which 12–22 samples were taken, varied from 1.5 to 10.5 hr.

Samples were removed and quenched by cooling to room temperature. The absorbance of the sodium 4-nitrophenoxide in the sample solution was immediately measured in 1-mm cells using a Beckman Model DB spectrophotometer with a Model SRL Sargent recorder attached; the appropriate 2-bromoacetanilide stock solution was used as the reference solution. The absorbance of the sample solution was measured at 405 nm and varied between an initial value of about 1.050 to a finel value of about 0.100 absorbance units, when further measurements were discontinued.

Good straight lines were obtained with a pseudo-first-order plot of the data up to 80–90% reaction. The data were analyzed using a least-squares fitting to the best straight line. The slope error was usually between 0.40 and 0.90%

Registry No.—Sodium *p*-nitrophenoxide, 824-78-2.

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