# Nucleophilic Substitution Reactions of 1-Halogeno-4-COR-2-nitrobenzenes and 1-Halogeno-6-COR-2-nitrobenzenes with Sodium Benzenethiolate and Piperidine. Can an "Inverted Built-In Solvation" Be Responsible for the Peculiar Activation by an *o*-Carboxamido Group in $S_NAr$ Reactions with an Anionic Nucleophile?

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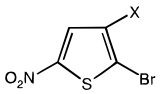
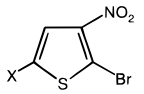
A kinetic study of the title reactions has allowed an interpretation of the higher efficiency of an *o*-carboxamido group with respect to an *o*-carbomethoxy group in activating the benzenethiolate-dehalogenation reactions in methanol ($k_{CONH_2}/k_{CO_2Me}$ 2.2−3.0) as due to an interaction between the anionic nucleophile and the hydrogen atoms of the carboxamido group. An inversion of the activating power of the two groups ($k_{CONH_2}/k_{CO_2Me}$ 0.14) in the reactions with the same nucleophile has been observed when they are in a *para*-position. Moreover, for piperidino-dehalogenation reactions in methanol $k_{CONH_2}/k_{CO_2Me}$ ratios less than unity (0.2−0.6) have been observed independently of the position (*ortho* or *para*) of the carboxamido and carbomethoxy groups with respect to the reaction center.

Recently, in a study of the reactivity of some 2-bromo-5-nitro-3-X-thiophenes (**1**) and of 2-bromo-3-nitro-5-X-thiophenes (**2**) with sodium benzenethiolate or piperidine in methanol, we observed[1] that a carboxamido group in an *ortho*-like position with respect to the reaction center in the reaction with the anionic nucleophile exerts an activating effect that is not observed either with a neutral nucleophile (piperidine) or when this group is in a *para*-like position. This behavior could be evidenced by



1

nucleophile: sodium benzenethiolate
$(k)_{CONH_2}/(k)_H$: 919
$(k)_{CO_2Me}/(k)_H$: 419
nucleophile: piperidine
$(k)_{CONH_2}/(k)_H$: 150
$(k)_{CO_2Me}/(k)_H$: 488



2

nucleophile: sodium benzenethiolate
$(k)_{CONH_2}/(k)_H$: 91
$(k)_{CO_2Me}/(k)_H$: 536
nucleophile: piperidine
$(k)_{CONH_2}/(k)_H$: 62.4
$(k)_{CO_2Me}/(k)_H$: 204

comparing the activation determined by carbomethoxy and carboxamido groups.[2] Thus, at 20 °C for **1** and **2** reacting with sodium benzenethiolate, $k_{CONH_2}/k_{CO_2Me}$ ratios 2.2 and 0.17, respectively, were observed, while for both **1** and **2** reacting with piperidine $k_{CONH_2}/k_{CO_2Me}$ ratios less than unity (*ca.* 0.3) were measured.

This peculiar effect of an *o*-carboxamido group was related[1] to some "interactions between the *ortho*-carboxamido group and the benzenethiolate anion causing a local increase in the effective concentration of the anionic nucleophile which would, in turn, increase the reactivity".

This interaction could be a hydrogen bond interaction between benzenethiolate ion and the hydrogen atoms of the *o*-carboxamido group. In fact, when the hydrogen atoms are substituted by methyl groups (in **1**: X = $CONMe_2$) a dramatic reduction of reactivity is observed in benzenethiolate-debromination ($k_{CONH_2}/k_{CONMe_2}$ *ca.* 500), "which can, only in part, be related to a steric effect similar to that observed in piperidino-debromination ($k_{CONH_2}/k_{CONMe_2}$ 8.1)".[1]

These kinetic data proved useful in giving a new interpretation of the results obtained by Miller and Williams[4] in a study of the methoxydechlorination reaction of some 1-chloro-4-COR-2-nitrobenzenes (**3**: L = Cl; $k_{CONH_2}/k_{CO_2Me}$ 0.17 at 50 °C) and of some 1-chloro-2-COR-4-nitrobenzenes (**4**: L = Cl, $k_{CONH_2}/k_{CO_2Me}$ 2.7 at 50 °C]. As a matter of fact, from the observation of a lower and a larger effect of carboxamido compared to the carbomethoxy group from the *para*- and the *ortho*- positions, respectively, these authors claimed that "some specific effect is seen to be required and it is here ascribed to Cl···H···N hydrogen bonding. This, together with the absence of O···O repulsive forces, more than counterbalances the effect of greater displacement of the whole group from the ring plane, when the $NH_2$ rather than the C=O is toward the Cl atom" and "the hydrogen bonding enhances the electronegativity of the Ar−Cl bond resulting in acceleration, and also weakens the Ar−Cl bond with the same result".[4]

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[⊗] Abstract published in *Advance ACS Abstracts,* April 15, 1997.

(1) Noto, R.; Frenna, V.; Consiglio, G.; Spinelli, D. *J. Chem. Res., Synop.* **1991**, 270−271; *J. Chem. Res., Miniprint* **1971**, 2701−2710.

(2) The carbomethoxy group ($\sigma_p$ −0.74)[3] is expected to be more efficient than the carboxamido group ($\sigma_p$ −0.62)[3] in activating a $S_NAr$. Indeed, the lower internal conjugation in $-CO_2R$ than in $-CONH_2$ makes the first group more able to help the negative charge delocalization.

(3) Exner, O. In *Correlation Analysis of Chemical Data*; Plenum Press: New York and London, 1988; p 61.

(4) Miller, J.; Williams, V. A. *J. Am. Chem. Soc.* **1954**, *76*, 5482−5484.

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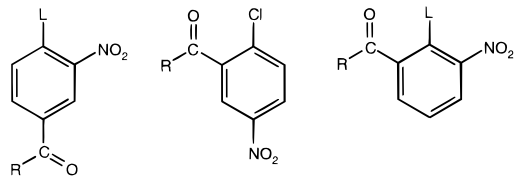


**3** **4** **5**

L = Cl, Br, I

**a** : R = $NH_2$

**b** : R = OMe

The results obtained by us by studying the kinetic effects of carboxamido and carbomethoxy groups in thiophenes **1** and **2** induced us to question this interpretation. Indeed, the hydrogen bonding suggested by Miller and Williams would be effective in activating $S_NAr$ with both anionic (*e.g.*, methoxide or benzenethiolate) and neutral (amines: *e.g.*, piperidine) nucleophiles. In contrast, the greater effectiveness of the *o*-carboxamido group with respect to the *o*-carbomethoxy group was observed only with anionic nucleophiles, *i.e.*, with reagents that can give in some manner a local increase of nucleophile concentration, eventually *via* a hydrogen bond formation between the hydrogen atoms of carboxamido group and the anionic nucleophiles.

In order to gain further information on the relative activating power of carbomethoxy and carboxamido groups we have extended our studies in this field on the basis of the following considerations. Firstly, the interpretation of data offered by Miller and Williams makes no differentiation between anionic and neutral nucleophiles, while our data with thiophene derivatives give a different response; therefore, we have studied an anionic and a neutral nucleophile to ascertain this point. Secondly, since these authors explain their results on the grounds of Halg···H···N hydrogen bonding, which would weaken the $C_{Ar}$−Halg bond, we have extended the investigation to bromine and iodine in addition to chlorine, because the three halogens have different hydrogen-bonding forming abilities[5a] as well as different bond strengths[5b] and different polarizabilities[5c] of the relevant $C_{Ar}$−Halg bonds. Finally, Miller and Williams assumed that the O···O repulsive forces, particularly important in the case of carbomethoxy group, disfavor the reactions where this substituent is involved with respect to those of the corresponding carboxamides: to lessen these interactions we have tested an anionic sulfur nucleophile instead of an anionic oxygen nucleophile.[5d]

Thus, we have studied the reactivity with sodium benzenethiolate (in methanol) and with piperidine (in methanol and benzene) of 1-halogeno-4-COR-2-nitrobenzenes (in **3**: L = Cl, Br, I; R = $NH_2$, OMe) and 1-halogeno-6-COR-2-nitrobenzenes (in **5**: L = Cl, Br, I; R = $NH_2$, OMe). Substrates **5** have been preferred to **4** in order to make a more homogeneous comparison. In fact, both compounds **3** and **5** contain a nitro group *ortho* to the reaction center which assures the occurrence of comparable proximity effects, particularly in the case of neutral nucleophiles (*e.g.*, piperidine, see below).

## Results and Discussion

**Benzenethiolate- and Piperidino-Dehalogenation Reactions of 3 and 5 in Methanol.** Kinetic data measured at three different temperatures together with the relevant thermodynamic data are collected in Tables 1 and 2.

The reactivity ratios measured for benzenethiolate-dehalogenation reactions in methanol of compounds **3** and **5** furnish results similar to those obtained by Miller and Williams in the methoxy-dechlorination of compounds **3** and **4**. Moreover, the ratios are practically independent of the halogen present [at 35 °C in **5**: $k_{CONH_2}/k_{CO_2Me}$ 2.2, 3.0, and 2.5 for L = Cl, Br, and I, respectively; in **3**: $k_{CONH_2}/k_{CO_2Me}$ 0.14 for all the three halogens]. Bearing in mind the differences in the electronegativities,[5e] in the abilities to give hydrogen bonding,[5a] in the strengths[5b] and in the polarizabilities[5c] of the $C_{Ar}$−Halg bond and in the volumes of the halogens used, the results obtained can hardly agree with the hypothesis of Miller and Williams.[4]

However, to gain information on the peculiar activation of the *o*-carboxamido substituent we have extended our study to the piperidino-dehalogenation reactions of substrates **3** and **5** in methanol. The reactivity ratios obtained, always less than unity [at 35 °C, in **5**: $k_{CONH_2}/k_{CO_2Me}$ 0.27, 0.59, and 0.29 in **3**: $k_{CONH_2}/k_{CO_2Me}$ 0.20, 0.22, and 0.24 for L = Cl, Br, and I, respectively], are not consistent with the hypothesis of Miller and Williams[4] on the general activation of the *o*-carboxamido group.

Indeed, in the piperidino-dehalogenation reactions in methanol, the carboxamido and carbomethoxy groups show the same sequence of activating ability in both the *ortho*- and the *para*-positions (the carbomethoxy group is more activating than the carboxamido group), in contrast with the proposed occurrence of a L···H···N hydrogen bonding suggested by Miller and Williams, which should be operating with both anionic and neutral nucleophiles in **5**. In every case, the activation by the carboxamido group with respect to the activation by the carbomethoxy group should be favored.

The *ortho*/*para* ratios[6] ($k_5/k_3$) at 35 °C in methanol for the two activating groups are consistent with our indications: indeed, they indicate a peculiar activation by the *o*-carboxamido group only with sodium benzenethiolate (R = $NH_2$: $k_5/k_3$ 0.22−0.30; R = OMe: $k_5/k_3$ 0.013−0.018) and not with piperidine (R = $NH_2$, OMe $k_5/k_3$ 0.03−0.08).

**Piperidino-Dehalogenation Reactions of 3 and 5 in Benzene.** Kinetic data measured at three different temperatures together with the relevant termodynamic data are collected in Table 3.

The kinetic data obtained show that in piperidino-dehalogenation reactions the reactivity of *o*- and *p*-COR halogeno compounds **3** and **5** is affected by the nature of the solvent used. Thus, the reactivity ratios calculated for **3** in benzene (*i.e.*, for the *p*-COR compounds) are always less than unity (at 35 °C: $k_{CONH_2}/k_{CO_2Me}$ 0.27, 0.29, and 0.21 for L = Cl, Br, and I, respectively), which is analogous to the situation observed in methanol. In contrast, reactivity ratios near unity are observed for **5** (*i.e.*, for *o*-COR compounds, at 35 °C: $k_{CONH_2}/k_{CO_2Me}$ 1.1, 1.3, and 1.5 for L = Cl, Br, and I, respectively] that show that for the *o*-COR compounds the ratios are significantly solvent-dependent. Usually, on going from a protic and polar solvent (*e.g.*, dioxane/water, methanol) to an aprotic

(5) Isaacs, N. S. In *Physical organic chemistry*; Longman Scientific & Technical: Harlow, 1987; (a) pp 62−64; (b) pp 36−37; (c) pp 246−247; (d) pp 456−457; (e) p 31; (f) pp 171−172.

(6) It must be noted that all of the *ortho*/*para* ratios are lower than unity, indicating the occurrence of a significant kinetic primary steric effect (e.g., see: Miller, J. *Aromatic Nucleophilic Substitution*; Elsevier: Amsterdam, 1968; pp 95 and 350 and references therein) in the *ortho*-isomers because of the 2,6-disubstitution.

**Table 1. Kinetic Constants and Activation Parameters for the Reactions of 3a, 3b, 5a, and 5b with Sodium Benzenethiolate in Methanol**

| compd | $10^3k$/M$^{-1}$ s$^{-1}$ (°C) | $\Delta H^{\ddagger}$ [a]/kJ M$^{-1}$ | $-\Delta S^{\ddagger}$ [b]/JK$^{-1}$ M$^{-1}$ |
|---|---|---|---|
| **3a**, L = Cl | 2.04 (15.05) 5.33 (25.20) 12.3 (35.00) | 64.0 | 74 |
| **3a**, L = Br | 12.8 (25.03) 29.6 (35.11) 63.0 (45.00) | 60.4 | 78 |
| **3a**, L = I | 12.1 (24.95) 28.9 (35.05) 67.3 (45.02) | 64.9 | 64 |
| **3b**, L = Cl | 16.7 (15.20) 38.8 (25.15) 90.1 (35.10) | 60.0 | 70 |
| **3b**, L = Br | 40.0 (15.12) 91.3 (25.04) 203 (35.10) | 57.5 | 72 |
| **3b**, L = I | 36.9 (14.92) 91.4 (24.93) 205 (35.04) | 60.4 | 62 |
| **5a**, L = Cl | 1.30 (25.20) 3.46 (35.00) 8.65 (44.93) | 73.3 | 54 |
| **5a**, L = Br | 3.57 (25.02) 8.92 (35.14) 22.9 (45.12) | 70.4 | 56 |
| **5a**, L = I | 2.68 (24.98) 6.38 (35.03) 14.7 (44.88) | 64.9 | 76 |
| **5b**, L = Cl | 0.622 (25.03) 1.61 (35.12) 3.86 (45.84) | 66.8 | 82 |
| **5b**, L = Br | 1.27 (25.03) 3.09 (35.12) 7.45 (45.90) | 64.5 | 84 |
| **5b**, L = I | 0.975 (24.98) 2.59 (35.03) 6.28 (44.87) | 71.3 | 63 |

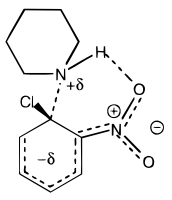
[a] At 20 °C; the maximum error is 2.1 kJ M$^{-1}$. [b] At 20 °C; the maximum error is 7 JK$^{-1}$ M$^{-1}$.

**Table 2. Kinetic Constants and Activation Parameters for the Reactions of 3a, 3b, 5a, and 5b with Piperidine in Methanol**

| compd | $10^6k$/M$^{-1}$ s$^{-1}$ (°C) | $\Delta H^{\ddagger}$ [a]/kJ M$^{-1}$ | $-\Delta S^{\ddagger}$ [b]/JK$^{-1}$ M$^{-1}$ |
|---|---|---|---|
| **3a**, L = Cl | 24.5 (20.02) 54.8 (29.99) 123 (40.12) | 58.7 | 132 |
| **3a**, L = Br | 32.9 (19.95) 74.2 (30.05) 164 (39.98) | 58.6 | 130 |
| **3a**, L = I | 8.02 (20.03) 20.1 (30.03) 47.4 (40.03) | 65.3 | 119 |
| **3b**, L = Cl | 137 (19.98) 293 (30.02) 592 (40.10) | 53.0 | 138 |
| **3b**, L = Br | 168 (19.98) 361 (30.02) 725 (39.96) | 53.3 | 135 |
| **3b**, L = I | 38.0 (19.98) 82.1 (30.10) 198 (39.96) | 60.4 | 123 |
| **5a**, L = Cl | 0.698 (20.00) 1.90 (30.02) 5.24 (40.10) | 74.0 | 110 |
| **5a**, L = Br | 2.15 (20.00) 5.67 (30.05) 14.9 (39.95) | 71.5 | 109 |
| **5a**, L = I | 0.351 (20.00) 1.11 (30.05) 2.97 (40.02) | 78.9 | 99 |
| **5b**, L = Cl | 2.76 (20.00) 7.71 (30.02) 18.7 (40.10) | 70.2 | 111 |
| **5b**, L = Br | 4.09 (20.00) 10.9 (30.05) 23.0 (39.98) | 63.5 | 131 |
| **5b**, L = I | 1.42 (20.00) 3.97 (30.05) 9.74 (40.10) | 70.6 | 115 |

[a] At 20 °C; the maximum error is 2.1 kJ M$^{-1}$. [b] At 20 °C; the maximum error is 7 JK$^{-1}$ M$^{-1}$.

and apolar solvent (*e.g.*, benzene, toluene) the effectiveness of the solvent to delocalize the charges in the transition state (*e.g.*, by hydrogen bonding, dipolar solvation) is reduced.[5f] On the other hand, an *ortho*-substituent with large electron-withdrawing effects (*e.g.*, $NO_2$ or COR) is able to assist the course of the reaction by the so-called "built-in solvation".[7] In aprotic and apolar solvents this effect can result in a large increase in the reactivity with respect to the situation observed when the same substituent is in a *para*-position because in the *ortho*-isomer it decreases "the need for participation of solvent molecules in the transition state formation".[7] Thus, in the piperidino-dechlorination reactions in 75% methanol *o*- and *p*-chloronitrobenzene show similar reactivities (at 102 °C, $k_o/k_p$ 1.7), while in benzene the *ortho*-isomer is much more reactive than the *para*-isomer ($k_o/k_p$ 46), probably because of the formation of a transition state having the structure reported below:




**6**

The structure of the transition state for the *ortho*-isomer shows that the higher the negative charge on the *ortho* electron-withdrawing substituent (*e.g.*, a nitro group), the stronger are the electrostatic or the hydrogen-bonding interactions, and this favors the course of the reaction.

In **5**, there are two *ortho*-substituents ($NO_2$ and COR) able to exert "built-in solvation". Interestingly, the carbomethoxy group (with a lower internal conjugation with respect to carboxamido group) is more effective than the carboxamido group in increasing the reactivity because of its higher electron-withdrawing effect, but *vice versa*, the carboxamido group is more effective than the carbomethoxy group in increasing the reactivity on the grounds of its higher ability to assist the course of the reaction by "built-in solvation". Thus, the two effects exerted by the two groups [electron-withdrawing effect (higher for carbomethoxy group) and "built-in solvation" (higher for carboxamido group)] counterbalance each other in benzene in the case of the piperidino-dehalogenation reaction of **5**, and similar reactivity ratios are observed ($k_{CONH_2}/k_{CO_2Me}$ 1.1−1.5).

## Conclusions

The kinetic data collected for benzenethiolate- and piperidino-dehalogenation reactions of **3** and **5** in methanol allow the exclusion of the interpretation offered by Miller and Williams[4] concerning the course of the methoxy-dechlorination reactions of **3** and **4**.

The special effect exerted by an *o*-carboxamido group with anionic nucleophiles can be better interpreted according to the reaction scheme reported below. The interaction between an anionic nucleophile and the hydrogen atoms of the *o*-carboxamido group favors the course of the reaction by carrying in some way the nucleophile on the reaction center (the transition state can thus be directly formed or a hydrogen-bonded adduct can be formed along the reaction coordinates), and this effect counterbalances the higher electron-withdrawing effect of the *o*-carbomethoxy group.

The structure of the transition state **7** explains why 6-carboxamido-1-halogeno-2-nitrobenzenes (**5a**) react faster

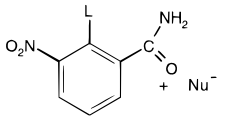
(7) Bunnett, J. F.; Morath, R. J. *J. Am. Chem. Soc.* **1955**, *77*, 5051−5055.

**Table 3. Kinetic Constants and Activation Parameters for the Reactions of 3a, 3b, 5a, and 5b with Piperidine in Benzene**

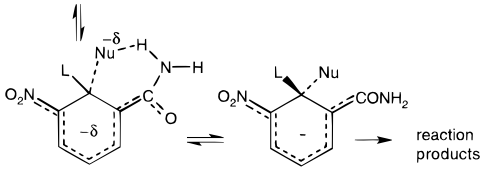
| compd | $10^4k$/$M^{-1}s^{-1}$ (°C) | $\Delta H^{\ddagger}$ [a]/kJ $M^{-1}$ | $-\Delta S^{\ddagger}$ [b]/$JK^{-1}$ $M^{-1}$ |
|---|---|---|---|
| **3a**, L = Cl | 3.27 (25.00) 6.08 (35.10) 9.98 (44.90) | 41.7 | 171 |
| **3a**, L = Br | 5.31 (25.06) 9.86 (35.10) 16.8 (45.03) | 43.0 | 163 |
| **3a**, L = I | 1.10 (25.04) 2.14 (35.03) 4.07 (45.02) | 49.1 | 156 |
| **3b**, L = Cl | 13.2 (25.06) 21.7 (35.10) 34.8 (45.03) | 35.8 | 180 |
| **3b**, L = Br | 20.1 (25.06) 33.8 (35.10) 55.2 (44.98) | 37.5 | 171 |
| **3b**, L = I | 5.97 (25.00) 10.3 (35.00) 17.7 (45.02) | 40.3 | 171 |
| **5a**, L = Cl | 1.04 (25.03) 2.03 (35.03) 3.74 (45.15) | 47.7 | 161 |
| **5a**, L = Br | 2.55 (24.98) 4.88 (35.00) 8.37 (45.03) | 44.3 | 165 |
| **5a**, L = I | 1.09 (24.95) 2.25 (35.35) 4.10 (45.00) | 49.6 | 154 |
| **5b**, L = Cl | 1.02 (25.03) 1.92 (34.98) 3.34 (44.98) | 44.4 | 172 |
| **5b**, L = Br | 2.00 (25.03) 3.85 (35.00) 6.70 (44.98) | 45.3 | 164 |
| **5b**, L = I | 0.717 (24.98) 1.47 (34.98) 2.85 (45.03) | 51.8 | 150 |

[a] At 20 °C; the maximum error is 2.1 kJ $M^{-1}$. [b] At 20 °C; the maximum error is 7 $JK^{-1}$ $M^{-1}$.

than 6-carbomethoxy-1-halogeno-2-nitrobenzenes (**5b**) with sodium benzenethiolate. Indeed, in the first case the nucleophilic substitution is anchimerically-assisted by hydrogen-bonding formation *via* a six-membered-ring transition state. This situation can be depicted as "inverted built-in solvation" with respect to that proposed by Bunnett and Morath,[7] as a comparison between **6** and **7** makes evident: in fact, in the two cases the host−guest (substrate−nucleophile) interactions are interchanged.




**5a**




**7**

In the case of 4-carboxamido-1-halogeno-2-nitrobenzenes **3** an analogous interaction does not favor the course of the reactions; in this case, it lowers the effective concentration of the anionic nucleophile.

Of course, this kind of interaction is much less meaningful with a neutral nucleophile. Thus, both *o*- and *p*-carbomethoxy groups are more effective than the corresponding carboxamido groups in activating the piperidino-dehalogenation reactions in methanol.

The piperidino-dehalogenation reactions of **3** and **5** in benzene show a different pattern because of the role now exerted by the "built-in solvation".

## Experimental Section

**Materials.** Methyl 4-chloro-3-nitrobenzoate[8] (**3b**, L = Cl), methyl 2-chloro-3-nitrobenzoate[8] (**5b**, L = Cl), methyl 4-bromo-3-nitrobenzoate[9] (**3b**, L = Br), methyl 2-bromo-3-nitrobenzoate[9] (**5b**, L = Br), 4-iodo-3-nitrobenzoic acid,[10] 2-iodo-3-nitrobenzoic[11] acid, methyl 2-iodo-3-nitrobenzoate[12] (**3b**, L = I), 4-chloro-3-nitrobenzamide[8] (**3a**, L = Cl), 4-bromo-3-nitrobenzamide[9] (**3a**, L = Br), piperidine,[13] benzenethiol,[14] methanol,[15] and benzene[16] were prepared and/or purified according to the methods reported.

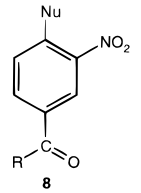
**Table 4. Physical and Spectroscopic Data of Compounds 8 and 9**

| compd | Nu | crystallization solvent | mp (°C) | $\lambda_{max}$ (log $\epsilon$) |
|---|---|---|---|---|
| **8a** | $SC_6H_5$ | ethanol | 199 | 364 (3.69)[a] |
| **8b** | $SC_6H_5$ | methanol−dioxane | 114 | 362 (3.67)[a] |
| **9a** | $SC_6H_5$ | methanol−dioxane | 199 | 360 (2.99)[a] |
| **9b** | $SC_6H_5$ | light petroleum | 60 | 360 (3.17)[a] |
| **8a** | $N(CH_2)_5$ | ligroine−benzene | 118 | 412 (3.28)[a] |
| | | | | 414 (3.35)[b] |
| **8b** | $N(CH_2)_5$ | light petroleum | 41 | 408 (3.34)[a] |
| | | | | 408 (3.35)[b] |
| **9a** | $N(CH_2)_5$ | ethanol | 158 | 386 (2.92)[a] |
| | | | | 360 (2.95)[b] |
| **9b** | $N(CH_2)_5$ | light petroleum | 61 | 370 (2.92)[a] |
| | | | | 370 (3.00)[b] |

[a] In methanol. [b] In benzene.

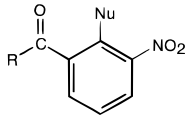
2-Chloro-3-nitrobenzamide (**5a**, L = Cl; mp 147−8 °C from aqueous methanol), 2-bromo-3-nitrobenzamide (**5a**, L = Br; mp 164 °C from benzene), 2-iodo-3-nitrobenzamide (**5a**, L = I; mp 225 °C from methanol), methyl 4-iodo-3-nitrobenzoate (**5a**, L = I; mp 105−6 °C from methanol), and 4-iodo-3-nitrobenzamide (**3a**; L = I; mp 157−8 °C from methanol) were prepared from the corresponding acids by the same methods used for the analogous chloro and bromo derivatives.

Sulfides and piperidino derivatives **8** and **9** were prepared according to the general methods reported, respectively, in refs 14 and 13. The relevant physical data are shown in Table 4. All the new compounds gave correct analyses.




**8**

Nu = $SC_6H_5$, $N(CH_2)_5$
**a** : R = $NH_2$
**b** : R = OMe




**9**

Nu = $SC_6H_5$, $N(CH_2)_5$
**a** : R = $NH_2$
**b** : R = OMe

(8) *Dictionary of Organic Compounds*; London: Eyre and Spottiswoode, 1953; Vol. I, p 536.
(9) *Dictionary of Organic Compounds*; London: Eyre and Spottiswoode, 1953; Vol. I, p 530.
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(11) Withmore, F. C.; Culhane, P. J.; Neher, H. J. *Organic Syntheses*, 2nd ed.; John Wiley and Sons, Inc.: New York, 1941; Collect. Vol. I, p 126.
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(15) Weissberger, A. *Technique of Organic Chemistry*, II ed.; Interscience Publ.: New York, 1963; Vol. *7*, p 334.

**Measurements.** The kinetics were followed spectrophotometrically as previously described. The kinetics constants were reproducible to within ±3%. The concentrations used were $(2-8) \times 10^{-3}$ M for substrates, $8 \times 10^{-2}-4 \times 10^{-1}$ M for piperidine, and $5 \times 10^{-3}-1 \times 10^{-2}$ M for sodium benzenethiolate (in presence of 1−3 times excess of benzenethiol). The wavelength and log $\epsilon$ values for UV spectral measurements are reported in Table 4.

(16) Vogel, A. I. *Practical Organic Chemistry*, III ed.; Longmans: London, 1961; p 173.

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