Reactions of Activated Aryl Sydnones with Electrophiles

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Electrophilic substitution on the aryl or sydnone ring of some *ortho*-substituted activated *N*-arylsydnones is reported.

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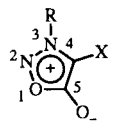
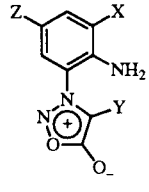
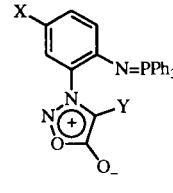
Generally, 3-arylsydnones (*cf.* **1**, R = Ar) react with halogenating agents (bromine [1a], chlorine [2a], *N*-bromosuccinimide [1b] or *N*-chlorosuccinimide [2b]) to give the corresponding 4-halogeno derivatives (*cf.* **2**, R = Ar). The absence of substitution upon the aryl ring can be attributed to the electron-withdrawing effect of the sydnone ring nitrogen (the N-3 position bears a substantial fractional positive charge [3]) and the activated nature of the sydnone ring C-4 location (the C-4 position bears a substantial fractional negative charge [4]). However, some years ago we showed [5,10] that aryl ring bromination can occur if the aryl ring is sufficiently activated. Thus, bromination of 3-(2-aminophenyl)sydnone (**3**) gave a mixture of unreacted starting material (36%) [6], 3-(2-amino-5-bromophenyl)sydnone (**4**) {13%} [6], 4-bromo-3-(2-amino-5-bromophenyl)sydnone (**5**) {25%} and a trace of the tribromo species **6** on treatment with one equivalent of bromine [5]. With five equivalents, only the tribromo compound **6** was formed.



1, X = H
2, X = Br, Cl



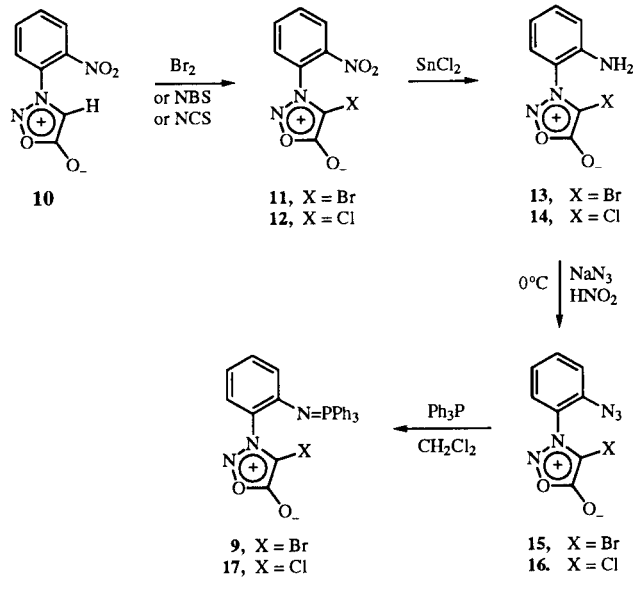
3, X,Y,Z = H
4, X,Y = H, Z = Br
5, X = H, Y,Z = Br
6, X,Y,Z = Br



7, X = Y = H
8, X = Br, Y = H
9, X = H, Y = Br

Since sydnones are convenient precursors to hydrazines and pyrazoles *via* treatment with hydrochloric acid [7] and acetylene cycloaddition [8], respectively, selectively substituted congeners (aryl or sydnone ring) could be of considerable utility. Accordingly, the present study was undertaken to explore the selectivity of aryl or sydnone ring electrophilic aromatic substitution upon activated sydnones such as 3-(2-aminophenyl)sydnone (**3**) and triphenylphosphine 2-(3-sydnonyl)phenylimide (**7**) [9]. Since, as discussed previously, the former had undergone aryl ring bromination in competition with the sydnone ring it was decided first to attempt the optimization of this process. It seemed likely that the selectivity of the reaction could be enhanced by the use of a less reactive, solid brominating agent which could be added in a more controlled fashion. Thus, bromination of **3** with *N*-bromosuccinimide (NBS) was examined. Addition of NBS to **3** in portions over 30 minutes at 0° and subsequent stirring for 3 hours gave a 78% yield of the mono-bromoaryl product **4**, identical to an authentic sample [5]. In light of this remarkable result it was of interest to extend the study to the bulky, activated (but less so than **3**) triphenylphosphine 2-(3-sydnonyl)phenylimide (**7**). Therein, when treated with NBS under carefully controlled conditions, **7** gave a single product in 78% yield which showed an apparent sydnone C-H stretch at 3143^{-1} in its infrared spectrum, strongly suggesting its identity as **8** rather than the 4-bromo isomer **9**. However, in activated aryl sydnones it has been demonstrated previously that the most shielded aryl hydrogens exhibit similar absorptions to the sydnone ring hydrogen in both infrared and nmr spectra [10]. Accordingly, for unambiguous assignment, it was elected to prepare both triphenylphosphine 2-(4-bromo-3-sydnonyl)phenylimide (**9**) and its 4-bromo congener **8** as shown in Schemes 1 and 2, respectively.

Scheme 1



10

11, X = Br
12, X = Cl

13, X = Br
14, X = Cl

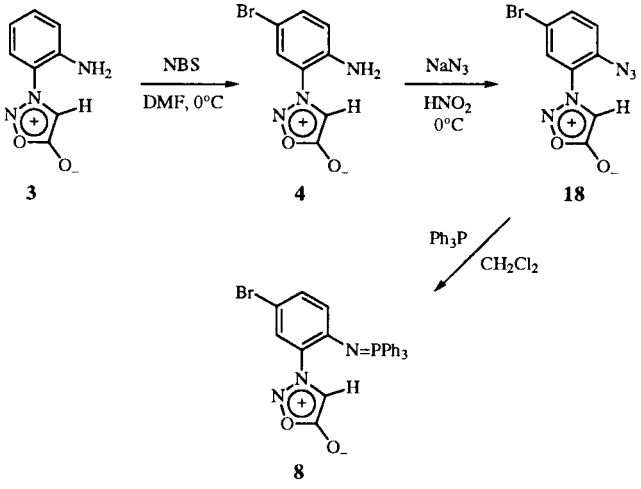
15, X = Br
16, X = Cl

9, X = Br
17, X = Cl

Thus, 4-bromo-3-(2-aminophenyl)sydnone (**13**) {prepared by stannous chloride reduction of the nitro con-

gener **11** [11] as reported previously [5]} was diazotized in the presence of sodium azide to yield the azido species **15** in 54% yield. The latter showed the characteristic azide and sydnone C=O stretching peaks (2213 and 1763 cm^{-1}, respectively) in its infrared spectrum. Subsequent reaction with triphenylphosphine in dichloromethane at room temperature gave triphenylphosphine 2-(4-bromo-3-sydnonyl)phenylimide (**9**) in 70% yield. Comparison (ir, tlc, mp) of the latter with the product formed by direct bromination of **7** showed it to be different and, accordingly, it seemed likely that the isomeric product **8** had been the product obtained by NBS treatment. This was confirmed by synthesis (Scheme 2). Accordingly, the bromoarylsydnone **4** was diazotized in the presence of sodium azide to give 3-(2-azido-5-bromophenyl)sydnone

Scheme 2



(**18**) in 74% yield which was transformed to the target molecule **8** in 78% yield by treatment with triphenylphosphine in dichloromethane. Comparison (ir, tlc, mp) with the bromo product from NBS and **7** showed both to be identical. Apparently, the iminophosphoranyl group is sufficiently activating to allow aryl ring bromination in competition with the sydnone ring. Its bulky nature presumably also plays a part in precluding reaction at the sydnone ring 4-position.

Having shown that direct aryl ring bromination of triphenylphosphine 2-(3-sydnonyl)phenylimide (**7**) was possible, it was decided to extend this concept to other electrophiles, especially since the utility of **7** as a precusor to fused ring sydnones would be considerably enhanced should successful transformations occur.

Chlorinations of Activated Aryl Sydnones.

Chlorination of triphenylphosphine 2-(3-sydnonyl)-phenylimide (**7**) was initially attempted with *N*-chlorosuccinimide (NCS) according to the NBS bromination protocol. However, after six hours at 0° and a further four hours at room temperature no reaction had occurred. The reaction was then carried out at room temperature for twenty four hours to yield what seemed to be triphenylphosphine 2-(4-chloro-3-sydnonyl)phenylimide (**17**). Although the infrared spectrum of the product showed the disappearance of the sydnone CH stretching vibration at 3150 cm^{-1} in its infrared spectrum, it was still elected to substantiate that this was indeed the 4-substituted product by unambiguous synthesis (especially since bromination favored the aryl ring) [Scheme 1]. Accordingly, 4-chloro-3-(2-nitrophenyl)sydnone (**12**) was prepared (in 56% yield) from direct chlorination of 3-(2-nitrophenyl)sydnone (**3**) with NCS. Reduction to 4-chloro-3-(2-aminophenyl)-sydnone (**14**) with stannous chloride dihydrate and subsequent conversion to 4-chloro-3-(2-azidophenyl)sydnone (**16**) was effected in 66% yield and 69% yield, respectively, according to the protocols used for the 4-bromo congeners. The target molecule, triphenylphosphine 2-(4-chloro-3-sydnonyl)phenylimide (**17**), was prepared by the action of triphenylphosphine on **16**. Comparison (tlc, mp, ir) with the product obtained from the direct chlorination of triphenylphosphine 2-(3-sydnonyl)phenylimide (**7**) showed both to be identical. This anomalous result (compared to bromination) is probably due to the greater reactivity and smaller size of the chlorine atom in comparison to the bromine atom, which allows accessibility to the sydnone C-H. To further examine the chlorination of activated aryl sydnones, it was of interest to see if 3-(2-aminophenyl)sydnone (**3**) would be affected similarly or if the chlorine would be directed to the aryl ring as in the direct bromination. Thus, 3-(2-aminophenyl)sydnone (**3**) was reacted with NCS in *N,N*-dimethylformamide. After 24 hours, the final sample was a mixture of 3 major products and a small amount of unreacted starting material. After column chromatography one of the products obtained was 4-chloro-3-(2-aminophenyl)sydnone (**14**) [24%]; the other two products could not be separated. The results of this reaction again suggest that the chlorine atom in NCS is much more reactive than the bromine atom in NBS and is, hence, not as regioselective. While the yields are low, this reaction does provide an alternative way to prepare the 4-chloro species and, accordingly, it may be instructive to modify the reaction conditions in order to selectively chlorinate the aryl moiety.

Mercuration of Activated Aryl Sydnones.

To continue our study, direct mercuration of activated aryl sydnones was the next reaction of choice since mercuric chloride is known to react with 3-phenylsydnone to give the corresponding 4-mercurichloro species [12] and subsequent conversion to the 4-iodo, bromo and chloro species has been reported [13].

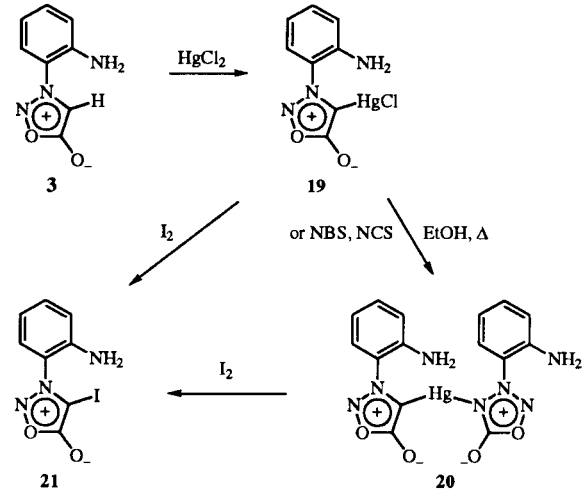
Direct mercuration of triphenylphosphine 2-(3-sydnonyl)phenylimide (**7**) with mercuric chloride gave confusing results. While there were changes in the infrared spectrum and tlc characteristics of the product (compared to the starting material) the mercury had apparently not reacted at the 4-position (the sydnone C-H stretching vibration was still apparent in the infrared spectrum). To determine if the mercury had indeed complexed with **7**, the product was reacted with iodine; the starting material **7** was obtained in 67% yield. In addition, when the product was reacted with sodium borohydride the starting material was again obtained in 82% yield. These results suggest that the mercuric chloride did not react with the phosphineimide and that the product was perhaps merely the starting material contaminated with mercuric chloride. However, when mercuric chloride was reacted with 3-(2-aminophenyl)sydnone (**3**), using a modification of the protocol reported in the literature [12], after 24 hours the expected 4-mercurichloro-3-(2-aminophenyl)sydnone (**19**) was apparently produced. Upon attempted recrystallization in hot ethanol this compound was converted to the bis-mercury species **20**. Both products reacted with iodine to provide 4-iodo-3-(2-aminophenyl)sydnone (**21**) in 65% and 63% yield, respectively (Scheme 3). These findings encouraged the possibility that the 4-bromo and 4-chloro congeners might be prepared from **19**.

However, direct bromination of **19** with one equivalent of bromine after 4 hours produced 4-mercuri bis[3-(2-aminophenyl)sydnone] (**20**) instead of the expected 4-bromo-3-(2-aminophenyl)sydnone (**13**). When the reaction was carried out with 3 equivalents of bromine, it gave 4-bromo-3-(2-amino-3,5-dibromophenyl)sydnone (**6**) in 72% yield.

Chlorination of 4-mercurichloro-3-(2-aminophenyl)-sydnone (**19**) with NCS also gave confusing results. The infrared spectrum revealed changes in the NH region, however, nmr analysis suggested that the compound might be 4-mercuri bis[3-(2-aminophenyl)sydnone] (**20**). Since the mercury substituted products could not be distinguished by tlc, it was elected to try the above iodine and sodium borohydride protocols in an effort to identify this product. The reaction with iodine gave 4-iodo-3-(2-aminophenyl)sydnone (**21**) and treatment with sodium borohydride gave 3-(2-aminophenyl)sydnone (**3**), suggesting that the product might indeed be **20**. Recrystallization attempts in methylene chloride gave back the starting material whereas recrystallization with hot 95% ethanol produced **20**. Similar results were also obtained from direct bromination of 4-mercurichloro-3-(2-aminophenyl)sydnone (**19**) with NBS (after 10 hours of stirring at 0°) [Scheme 3].

Although mercuric chloride did not react with triphenylphosphine 2-(3-sydnonyl)phenylimide (**7**) the results

Scheme 3



obtained suggest that since a 4-chloromercuri group can be removed by sodium borohydride, it may be used as a protective group for that position. In addition, these findings indicate that the bulky iminophosphoranyl group sterically hinders electrophillic substitution with electrophiles as large as mercuric chloride. For future studies it might be possible to synthesize compounds such as the mercury substituted triphenylphosphine 2-(3-sydnonyl)-phenylimide after the mercury has been attached to the sydnone 4-position.

In conclusion, it has been shown that regiospecific functionalization of the aryl or sydnone ring of activated 3-arylsydnones is sometimes possible. It should also be possible to use these findings *en route* to unusually substituted hydrazines or heterocycles since sydnones are precursors to such species [7, 8].

EXPERIMENTAL [14]

4-Bromo-3-(2-azidophenyl)sydnone (**15**).

To a stirred suspension of 4-bromo-3-(2-aminophenysydnone (**13**) [0.282 g, 1.09 mmoles] in water (10 ml) and 12*N* hydrochloric acid (2.5 ml) was added a solution of sodium azide (0.302 g, 4.66 mmoles) in water (2.5 ml). After 15 minutes of stirring at 0°, sodium nitrite (0.196 g, 2.8 mmoles) in water (2 ml) was added dropwise over 30 minutes. After 1 hour of additional stirring, the product was filtered to give a tan precipitate. An additional, small amount of product was obtained by extraction of the initial filtrate with dichloromethane and subsequent work-up. The final product (0.177 g, 54% yield) was identical (mp, tlc, ir) to an authentic sample of 4-bromo-3-(2-azidophenyl)sydnone [9].

3-(2-Azido-5-bromophenyl)sydnone (**18**).

To a stirred suspension of 3-(2-amino-5-bromophenyl)-sydnone (**4**) [0.20 g, 7.8 mmoles] in water/12*N* hydrochloric

acid (1:1, 16 ml), was added a solution of sodium azide (0.90 g, 13.8 mmoles) in water (2.5 ml). After 15 minutes of stirring at 0°, sodium nitrite (0.55 g, 7.9 mmoles) in water (2 ml) was added dropwise over 30 minutes. After 2 hours of additional stirring the product was filtered to give a tan precipitate. An additional, small amount of product was obtained by extraction of the initial filtrate with dichloromethane and subsequent work-up. Recrystallization from ethanol produced the title compound as light tan crystals, 0.108 g (49% yield), mp 154-156°; ir: 3142 (aliphatic CH str), 2133, 2105 (N_3 str), 1730 (sydnone C=O str); nmr (deuteriodimethyl sulfoxide) δ 7.16-7.95 (m).

Anal. Calcd. for $C_8H_4BrN_5O_2$: C, 34.06; H, 1.43. Found: C, 34.11; H, 1.39.

4-Mercurichloro-3-(2-aminophenyl)sydnone (**19**).

To a stirred suspension of 3-(2-aminophenyl)sydnone (**3**) [2.0 g, 0.011 mole] and sodium acetate (3.7 g, 4.5 moles) in 50% methanol (10 ml) was added a solution of mercuric chloride (3.98 g, 0.0147 mole) in 50% methanol (10 ml). After stirring for 24 hours, the product was filtered to give a tan solid, 3.94 g (84%), mp 170-171°. Attempted crystallization in hot 95% ethanol converted the solid to 4-mercuri bis[3-(2-amino-phenyl)sydnone] (**20**), mp 182-184°; ir: 3409, 3332, 3228 (NH str), 1721 (sydnone C=O str); nmr (deuteriodimethyl sulfoxide): δ 5.29 (s, 2H), 7.01 (m, 4H).

Anal. Calcd. for $C_{16}H_{12}HgN_6O_4$: C, 34.75; H, 2.17. Found: C, 34.99; H, 2.35.

Direct Brominations.

3-(2-Amino-5-bromophenyl)sydnone (**4**).

N-Bromosuccinimide (0.5 g, 2.8 mmoles) was added in small portions with stirring to an ice cooled (0°) solution of 3-(2-aminophenyl)sydnone (**3**) [0.5 g, 2.8 mmoles] dissolved in *N,N*-dimethylformamide (3 ml). After cooling and stirring at 0° for 3 hours, ice/water (50 ml) was added to produce a yellow precipitate, 0.337 g (78% yield). The final product was identical (mp, ir, nmr) to an authentic sample of **4** [5].

4-Bromo-3-(2-amino-5-bromophenyl)sydnone (**5**).

a) From Direct Bromination of 4-Bromo-3-(2-aminophenyl)-sydnone (**13**).

N-Bromosuccinimide (0.212 g, 1.2 mmoles) was added in small portions with stirring to an ice cooled solution of 4-bromo-3-(2-aminophenyl)sydnone (**13**) [0.318 g, 1.2 mmoles] dissolved in *N,N*-dimethylformamide (3 ml). After cooling and stirring at 0° for 3 hours, ice/water (50 ml) was added. The yellow precipitate, 0.321 g (79% yield) was identical (mp, ir, nmr) to an authentic sample of **5** [5].

b) From Direct Bromination of 3-(2-Amino-5-bromophenyl)-sydnone (**4**).

N-Bromosuccinimide (0.097 g, 5.5 mmoles) was added in small portions with stirring to an ice cooled (0°) solution of 3-(2-amino-5-bromophenyl)sydnone (**4**) [0.140 g, 5.5 mmoles] dissolved in *N,N*-dimethylformamide (3 ml). After cooling and stirring at 0° for 3 hours, ice/water (50 ml) was added. The final product, 0.150 g (82% yield), was identical (mp, ir, nmr) to an authentic sample of **5** [5].

4-Bromo-3-(2-amino-3,5-dibromophenyl)sydnone (**6**).

By Bromination of 4-Mercurichloro-3-(2-aminophenyl)sydnone (**19**).

To a stirred suspension of 4-mercurichloro-3-(2-amino-phenyl)sydnone (**19**) [0.20 g, 0.49 mmole] in methanol/water (4:1) was added a solution of potassium bromide (0.78 g, 0.65 mmole) and bromine (0.1 ml, 1.59 mmoles) in water (16 ml). After 1.5 hours of stirring, ice water (30 ml) was added to precipitate the solid. The product was filtered to give a tan solid, 0.145 g (72% yield) which was identical (mp, ir, tlc) to an authentic sample of **6** [5].

Triphenylphosphine 2-(4-Bromo-3-sydnonyl)phenylimide (**9**).

To a stirred solution of 4-bromo-3-(2-azidophenyl)sydnone (**15**) [0.150 g, 5.3 mmoles] in dichloromethane (5 ml) was added triphenylphosphine (0.139 g, 5.3 mmoles) at room temperature. After 2 hours, the solvent was removed *in vacuo* and the solid product was recrystallized from dichloromethane to produce light yellow crystals of the title compound, 0.192 g (70% yield), mp 160-162°; ir: 3055 (aromatic CH str), 1755 (sydnone C=O str); nmr (deuteriodimethyl sulfoxide): δ 6.62-6.87 (m, 17H), 5.89 (q, 1H), 5.63 (d, 1H).

Anal. Calcd. for $C_{26}H_{19}BrN_3O_2P$: C, 60.48; H, 3.71; N, 8.14. Found: C, 60.61; H, 3.88; N, 8.28.

Triphenylphosphine 4-Bromo-2-(3-sydnonyl)phenylimide (**8**).

a) From Direct Bromination.

N-Bromosuccinimide (0.098 g, 3.76 mmoles) was added in small portions with stirring to an ice cooled (0°) solution of 2-(3-sydnonyl)phenylimide (**7**) [0.164 g, 3.76 mmoles] dissolved in *N,N*-dimethylformamide (3 ml). After cooling and stirring for 1.5 hours, ice/water (50 ml) was added. The precipitate was filtered, air dried, then recrystallized from 95% ethanol to give light yellow crystals; 0.152 g (78% yield), mp 165-166°; ir: 3143 (sydnone CH str), 3053 (aromatic CH str), 1738 (sydnone C=O str); nmr (deuteriodimethyl sulfoxide): δ 6.06-6.31 (m, 18H), 4.98 (d, 1H).

Anal. Calcd. for $C_{26}H_{19}BrN_3O_2P$: C, 60.48; H, 3.71; N, 8.14. Found: C, 60.11; H, 3.60; N, 7.91.

b) From 3-(2-Azido-5-bromophenyl)sydnone (**18**).

To a stirred solution of 3-(2-azido-5-bromophenyl)sydnone (18) [0.050 g, 0.18 mmole] in dichloromethane (5 ml) was added triphenylphosphine (0.046, 0.18 mmole) at room temperature. After 4 hours, the solvent was removed *in vacuo*. The product was filtered to give 0.068 g (74% yield) of a yellow solid which was identical (mp, ir, tlc) to an authentic sample of triphenylphosphine 4-bromo-2-(3-sydnonyl)phenylimide (**8**) prepared as above.

Attempted Bromination of 4-Mercurichloro-3-(2-amino-phenyl)sydnone (**19**).

a) Direct Bromination with NBS/DMF.

N-Bromosuccinimide (0.064 g, 0.364 mmole) was added in small portions with stirring to an ice cooled (0°) solution of 4-mercurichloro-3-(2-aminophenyl)sydnone (**19**) [0.150 g, 0.364 mmole] dissolved in *N,N*-dimethylformamide (5 ml). After cooling and stirring at 0° for 10 hours, the mixture was poured into ice water and then extracted with dichloromethane (4 x 25 ml). The combined extracts were washed with water (6 x 50 ml), dried (drierite) and evaporated *in vacuo* to give a pinkish-brown product in 0.035 g (38%) yield, mp 154-158°; ir: 3341, 3219 (NH str), 1727 (sydnone C=O str). Attempted recrystallization

from hot 95% ethanol converted the product to 4-mercuri bis[3-(2-aminophenyl)sydnone] (**20**) which was identified by comparison (tlc, ir, mp) with authentic material.

b) Direct Bromination with Bromine and Potassium Bromide.

4-Mercurichloro-3-(2-aminophenyl)sydnone (**19**) [0.20 g, 0.49 mmole] in methanol/water (4:1, 8 ml) was stirred for 10 minutes whereupon a solution of potassium bromide (0.78 g, 0.65 mmole) and bromine (0.10 g, 0.617 mmole) in water (3 ml) was added. After 1.5 hours of stirring, ice water (30 ml) was added to precipitate the solid. The product was removed by filtration to give a tan solid, 0.175 g (60%) which was identical (mp, ir, tlc) to an authentic sample of 4-mercuri bis[3-(2-aminophenyl)sydnone] (**20**).

Direct Chlorinations.

4-Chloro-3-(2-nitrophenyl)sydnone (**12**).

N-Chlorosuccinimide (0.638 g, 4.78 mmoles) was added gradually with stirring to a solution of 3-(2-nitrophenyl)sydnone (**10**) [0.900 g, 4.34 mmoles] in *N,N*-dimethylformamide (5 ml). After 2 hours of additional stirring at room temperature in a water bath, the mixture was poured into ice water and then extracted with dichloromethane (4 x 25 ml). The combined extracts were washed with water (6 x 50 ml), dried (drierite) and evaporated *in vacuo* to yield a brown solid which recrystallized from 95% ethanol as light tan crystals, 0.451 g (56% yield), mp 97-99°; ir: 3053 (aromatic CH str), 1779, 1748 (sydnone C=O str); nmr (deuteriodimethyl sulfoxide): δ 7.29-8.48 (m).

Anal. Calcd. for $C_8H_4ClN_3O_4$: C, 39.76; H, 1.66; N, 17.39. Found: C, 39.87; H, 1.69; N, 17.16.

4-Chloro-3-(2-aminophenyl)sydnone (**14**).

a) With Stannous Chloride Dihydrate.

Stannous chloride dihydrate (4.05 g, 3.6 mmoles) was added to a stirred suspension of 4-chloro-3-(2-nitrophenyl)sydnone (**12**) [0.869 g, 3.6 mmoles] in ethyl acetate (10 ml). After 35 minutes of stirring at 70°, followed by cooling to room temperature, water (25 ml) and sufficient sodium bicarbonate were added to neutralize the reaction mixture. The solution was then filtered and extracted with dichloromethane (5 x 25 ml). The combined extracts were dried (drierite), filtered and evaporated *in vacuo* to yield a solid which recrystallized from 95% ethanol to give the title compound as yellow needles, 0.402 g (66% yield), mp 120-121°; ir: 3433, 3344, 3266 (NH str), 1733 (sydnone C=O str); nmr (deuteriodimethyl sulfoxide): δ 4.21 (s, 2H), 7.31 (m, 4H).

Anal. Calcd. for $C_8H_2ClN_30_2$: C, 45.40; H, 2.84; N, 19.87. Found: C, 45.26; H, 2.78; N, 19.46.

b) With NCS.

N-Chlorosuccinimide (0.377 g, 2.8 mmoles) was added gradually with stirring to a solution of 3-(2-aminophenyl)sydnone (**3**) [0.5 g, 2.8 mmoles] in *N,N*-dimethylformamide (5 ml). After 24 hours of additional stirring at room temperature, the mixture was poured into ice water and then extracted with dichloromethane (4 x 25 ml). The combined extracts were washed with water (6 x 50 ml), dried (drierite) and evaporated *in vacuo* to give a brown solid (0.125 g) containing 4 products (tlc). After column chromatography, two of the products proved to be identical to authentic samples of 4-chloro-3-(2-aminophenyl)sydnone (**14**) [0.030 g] and starting material [0.005 g] in 24% yield and 4% yield, respectively.

The residue (0.045 g) from this reaction was a mixture of two products which proved impossible to separate by column chromatography.

4-Chloro-3-(2-azidophenyl)sydnone (**16**).

To a stirred suspension of 4-chloro-3-(2-aminophenyl)sydnone (**14**) [0.370 g, 1.75 mmoles] in a mixture of water (10 ml) and 12*N* hydrochloric acid (6.5 ml) was added a solution of sodium azide (0.864 g, 13.2 mmoles) in water (2.5 ml). After 15 minutes of stirring at 0°, sodium nitrite (0.550 g, 7.97 mmoles) in water (2 ml) was added dropwise over 30 minutes. After 1 hour of additional stirring, the precipitate was filtered, dried and recrystallized from 95% ethanol to give light brown crystals of the title compound, 0.290 g (69% yield), mp 128-130°; ir: 3100, 3060 (aromatic CH str), 2131, 2096 (N_3 str), 1784, 1749 (sydnone C=O str); nmr (deuteriodimethyl sulfoxide): δ 6.70-7.86 (m).

Anal. Calcd. for $C_8H_4ClN_5O_2$: C, 40.44; H, 1.70; N, 29.48. Found: C, 40.84; H, 1.87; N, 29.02.

Triphenylphosphine 2-(4-Chloro-3-sydnonyl)phenylimide (**17**).

a) From 4-Chloro-3-(2-azidophenyl)sydnone (**16**).

To a stirred solution of 4-chloro-3-(2-azidophenyl)sydnone (**16**) [0.100 g, 4.21 mmoles] in dichloromethane (5 ml) was added triphenylphosphine (0.112 g, 4.21 mmoles) at room temperature. After 2 hours, the solvent was removed *in vacuo* and the solid product was recrystallized from dichloromethane to produce light yellow crystals of the title compound, 0.101 g (51% yield), mp 135-136°; ir: 3051 (aromatic CH str), 1758 (sydnone C=O str); nmr (deuteriodimethyl sulfoxide): δ 6.43-6.55 (m, 17H), 5.99 (q, 1H), 5.35 (d, 1H).

Anal. Calcd. for $C_{26}H_{19}ClN_3O_2P$: C, 66.17; H, 4.06; N, 8.91. Found: C, 65.99; H, 4.05; N, 8.79.

b) With NCS.

N-Chlorosuccinimide (0.031 g, 0.227 mmole) was added gradually with stirring to a solution of triphenylphosphine 2-(3-sydnonyl)phenylimide (**7**) [0.100 g, 0.227 mmole] in *N,N*-dimethylformamide (3 ml). After 24 hours of additional stirring at room temperature, the mixture was poured into ice water and then extracted with dichloromethane (4 x 25 ml). The combined extracts were washed with water (6 x 50 ml), dried (drierite) and evaporated *in vacuo* to give the final product (0.052 g, 49%), identical (mp, ir, tlc) to an authentic sample of **17**.

Attempted Chlorination of 4-Mercurichloro-3-(2-aminophenyl)sydnone (**19**).

N-Chlorosuccinimide (0.063 g, 0.47 mmole) was added gradually with stirring to a solution of 4-mercurichloro-3-(2-aminophenyl)sydnone (**19**) [0.195 g, 0.47 mole] dissolved in *N,N*-dimethylformamide (2 ml). After 2 hours of additional stirring at room temperature in a water bath, the mixture was poured into ice water and then extracted with dichloromethane (4 x 25 ml). The combined extracts were washed with water (6 x 50 ml), dried (drierite), filtered and evaporated *in vacuo* to yield a brown solid which recrystallized from 95% ethanol as light tan crystals, 0.78 g (56% yield), mp 110-112°; ir: 3348, 3222 (NH str), 3053 (aromatic CH str), 1717 (sydnone C=O str).

The product was crystallized from hot 95% ethanol which converted it to 4-mercuri bis[3-(2-aminophenyl)sydnone] (**20**).

4-Iodo-3-(2-aminophenyl)sydnone (**21**).

a) From 4-Mercurichloro-3-(2-aminophenyl)sydnone (**19**).

4-Mercurichloro-3-(2-aminophenyl)sydnone (**19**) [0.5 g, 1.2 mmoles] was stirred for 10 minutes in methanol (5 ml). A solution of potassium iodide (2.67 g, 1.6 mmoles) and iodine (4.06 g, 1.6 mmoles) in methanol (5 ml) then was added to the reaction mixture. After 24 hours of stirring, the solvent was evaporated and the residue was dissolved in methylene chloride (25 ml), filtered and washed with saturated sodium sulfite (2 x 25 ml). The organic layer was dried (drierite) and evaporated to afford a solid residue which recrystallized from methylene chloride/petroleum ether to yield the title compound, 0.239 g (65% yield), mp 156-158°; ir: 3422, 3337 (NH str), 1720 (sydnone C=O str); nmr (deuteriochloroform): δ 5.21 (s, 2H, NH_2), 7.09 (m, 4H, aromatic).

Anal. Calcd. for $C_8H_6IN_3O_2$: C, 31.70; H, 2.00. Found: C, 31.60; H, 1.98.

b) From 4-Mercuri Bis[3-(2-aminophenyl)sydnone] (**20**).

4-Mercuri bis[3-(2-aminophenyl)sydnone] (**20**) [0.253 g, 0.451 mmole] was stirred for 10 minutes in methanol (5 ml). Then a solution of potassium iodide (2.67 g, 1.6 mmoles) and iodine (4.06 g, 1.6 mmoles) in methanol (5 ml) was added to the reaction mixture. After 24 hours of stirring, the solvent was evaporated and the residue was dissolved in methylene chloride (25 ml), filtered and washed with saturated sodium sulfite (2 x 25 ml). The organic layer was dried (drierite) and evaporated to give a yellow product, 0.081 g (59%), which proved to be identical (tlc, ir, mp) to an authentic sample of 4-iodo-3-(2-aminophenyl)sydnone (**21**).

Demercuration of 4-Mercurichloro-3-(2-aminophenyl)sydnone (**19**).

Sodium borohydride (0.60 g, 16.5 mmoles) was added in small quantities to a solution of 4-mercurichloro-3-(2-aminophenyl)sydnone (**19**) [0.10 g, 2.4 mmoles] in methanol (5 ml). After stirring for 30 minutes at room temperature, water (10 ml) was added and the solution was filtered to give a yellow product in (0.02 g) 47% yield. The final product was identical (mp, ir) to an authentic sample of 3-(2-aminophenyl)sydnone (**3**) [15].

Demercuration of 4-Mercuri Bis[3-(2-aminophenyl)sydnone] (**20**).

Sodium borohydride (0.75 g, 20.6 mmoles) was added in small quantities to a solution of 4-mercuri bis[3-(2-aminophenyl)sydnone] (**20**) [0.10 g, 0.178 mmole] in methanol (5 ml). After stirring for 30 minutes at room temperature, water (10 ml) was added and the solution was filtered to give a yellow product in (0.040 g) 63% yield which was identical (mp, ir) to an authentic sample of 3-(2-aminophenyl)sydnone (**3**) [15].

REFERENCES AND NOTES

[1] [a] C. V. Greco, M. Pesce and J. M. Franco, *J. Heterocyclic Chem.*, **3**, 391 (1966); [b] W. Baker, W. D. Ollis and V. D. Poole, *J. Chem. Soc.*, 307 (1949).

[2] [a] R. A. Eade and J. C. Earl, *J. Chem. Soc.*, 2307 (1948); [b] H.-J. Tien, M.-Y. Teh and C. Y. Huang, *J. Chin. Chem. Soc.*, **32**, 461 (1985).

[3] C. Tin-Lok, J. Miller and F. Stansfield, *J. Chem. Soc.*, 1213 (1964).

[4] M. Ohta and H. Kato, in Nonbenzenoid Aromatics, Vol 1, J. P. Snyder, ed, Academic Press, Inc, New York, NY, 1969.

[5] S. J. Hodson and K. Turnbull, *J. Heterocyclic Chem.*, **22**, 1223 (1985).

[6] The yields were determined after conversion to the corresponding sydnobenzotriazines with nitrous acid.

[7] C. R. Gelvin and K. Turnbull, *Helv. Chim. Acta*, **75**, 1931 (1992).

[8] R. Huisgen, R. Grashey, H. Gotthardt and R. Schmidt, *Angew. Chem.*, **74**, 29 (1962).

[9] W. C. Burson, III, D. R. Jones, K. Turnbull and P. N. Preston, *Synthesis*, 745 (1991).

[10] K. Turnbull, *J. Heterocyclic Chem.*, **22**, 965 (1985).

[11] F. D. Bellamy and K. Ou, *Tetrahedron Letters*, 839 (1984).

[12] J. M. Tien and I. M. Hunsberger, *J. Am. Chem. Soc.*, **83**, 178 (1961).

[13] M. Ohta and H. Kato, *Nippon Kagaku Zasshi*, **78**, 1653 (1957); *Chem. Abstr.*, **54**, 1503 (1960).

[14] All melting points were determined on a Mel-Temp apparatus and are uncorrected. Infared spectra (potassium bromide) were measured on a Perkin Elmer 1600 Fourier transform (FT) instrument and nuclear magnetic resonance spectra (^1H and ^{13}C) on an IBM NR/200 FTNMR at 200 MHz with tetramethylsilane as the internal standard, chemical shifts reported in ppm (δ). Combustion analyses were performed by Midwest Microlab, Indianapolis.

[15] R. A. Coburn and J. P. O'Donnell, *J. Org. Chem.*, **37**, 1707 (1972).