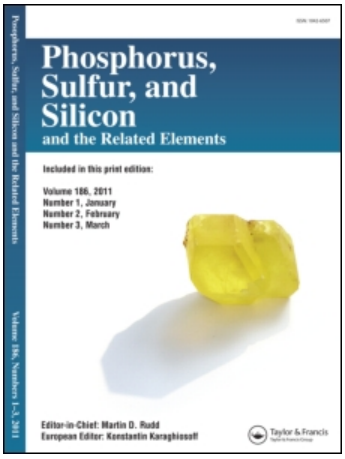


Phosphorus, Sulfur, and Silicon and the Related Elements

Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713618290

Chlorosulfonation of Some Aldimine-Isocyanate Cycloadducts

Richard J. Cremlyn[a]; Richard M. Ellam[a]; Sultan Farouk[a]
[a] University of Hertfordshire, England

To cite this Article Cremlyn, Richard J. , Ellam, Richard M. and Farouk, Sultan(2003) 'Chlorosulfonation of Some Aldimine-Isocyanate Cycloadducts', Phosphorus, Sulfur, and Silicon and the Related Elements, 178: 9, 1931 — 1941
To link to this Article: DOI: 10.1080/10426500390228611
URL: http://dx.doi.org/10.1080/10426500390228611

Phosphorus, Sulfur, and Silicon, 178:1931–1941, 2003

ISSN: 1042-6507 print / 1563-5325 online
DOI: 10.1080/10426500390228611

Taylor & Francis
Taylor & Francis Group

CHLOROSULFONATION OF SOME ALDIMINE-ISOCYANATE CYCLOADDUCTS

Richard J. Cremlyn, Richard M. Ellam, and Sultan Farouk
University of Hertfordshire, England

(Received March 25, 2003)

*Attempts to chlorosulfonate 1,4-diphenyl-1,3-diazetidin-2-one (**1**) failed, but the 3-methyl derivative (**2**) reacted with chlorosulfonic acid to give the* bis-*sulfonyl chloride (**3**), characterized as the sulfonamides **4** and **5**. 2,3,6-Triphenyl-2,3-dihydro-1,3,5-thiadiazin-4-one (**6**) with chlorosulfonic acid suffered an acid-catalyzed ring-opening reaction forming the sulfonyl derivatives (**8**, **9**) of N-phenyl-N′-thiobenzoylurea (**7**). Condensation of **8** and **9** with diethylamine afforded the diethylsulfonamide (**10**). Dibenzylideneethylenediamine (**11**) reacted with thiobenzoyl isocyanate at room temperature to yield the cycloadduct **12**; however at 90°C, N,N′-di (thiobenzoylcarbamoyl)ethylenediamine (**13**) was obtained. The cycloadduct **12** with chlorosulfonic acid gave the ring-opened disulfonyl chloride **14** and the diethylsulfonamide **15**. 1,6-Diphenylhexahydro-*s*-triazine-2,4-dione (**17**) was converted into the dimethyl derivative (**18**), which with chlorosulfonic acid afforded the* bis-*sulfonyl chloride (**19**), characterized as the sulfonamides **20–22**.*

Keywords: Chlorosulfonation; diazetidinone; hexahydro-*s*-thiazinedione; sulfonamides; thiadiazinone

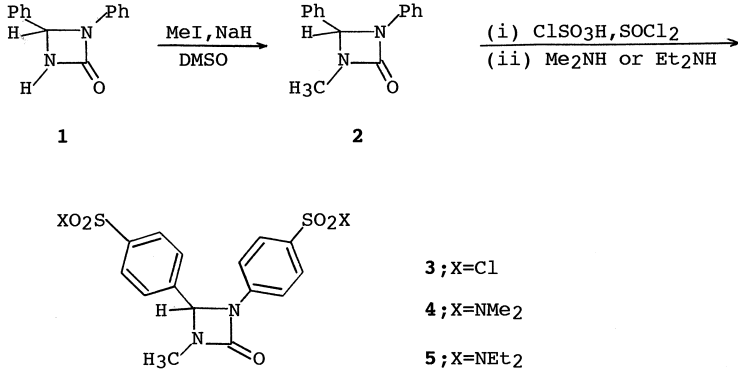
Chlorosulfonic acid is a widely used reagent for the sulfonation and chlorosulfonation of aromatic and heteroaromatic compounds.[1] The work described here continues our previous studies on the chlorosulfonation of heterocyclic compounds as a route to aryl-sulfonyl derivatives of potential biological activity.[1–4] In the present investigation we studied the chlorosulfonation of some aldimine-isocyanate adducts containing a cyclic urea grouping as a common structural feature, namely a 1,3-diazetidinone, thiadiazinone, and a hexahydro-*s*-thiazinedione.

Thanks are due to the British Technology Group (BTG, Biosciences Division) for the award of a research grant (SF); Dr. Richard A'Court (BTG) for his support and interest in the project; Glaxo Group Research for the microanalyses; Smith Kline Beecham for the FAB mass spectra.

Address correspondence to Richard M. Ellam, 4 Gomer Close, Hitchin, Herts SG4 8XP, U.K.

DISCUSSION

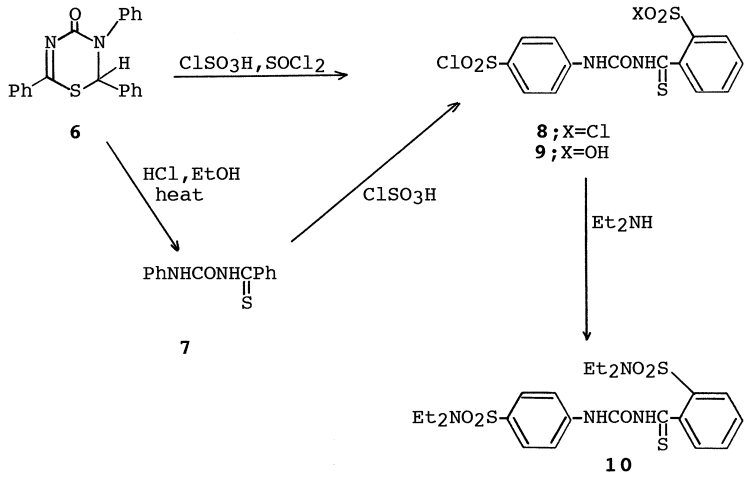
1,4-Diphenyl-1,3-diazetidin-2-one (**1**) was prepared by reaction of isocyanic acid on benzylideneaniline.[5] Attempts to chlorosulfonate **1** by treatment with excess chlorosulfonic acid (12 molar equivalents, or 3 molar equivalents in thionyl chloride) at room temperature (1 week), or at 80°C, were unsuccessful. The failure may be ascribed to hydrolytic decomposition of the crude sulfonyl chlorides during the aqueous acidic work-up procedures and resembles previous attempts to chlorosulfonate benzylidene-anilines.[5] This argument is supported by the observed instability of the diazetidinone (**1**) in both acidic and alkaline media.[6] Methylation of the diazetidinone (**1**) afforded the N-methyl derivative (**2**) (Scheme 1), which is relatively stable under acidic conditions. Hence, warming **2** with chlorosulfonic acid (6 molar equivalents) in thionyl chloride at 50°C gave the *bis*-sulfonyl chloride (**3**), characterized by formation of the sulfonamides **4** and **5**. The NMR spectral data for the latter two compounds supported the proposed pattern of *para*-sulfonation.



SCHEME 1

2,3,6-Triphenyl-2,3-dihydro-1,3,5-thiadiazin-4-one (**6**) was obtained by cycloaddition of 2-phenylthiazoline-4,5-dione with benzylideneaniline. Attempted chlorosulfonation of the cycloadduct **6** by treatment with excess chlorosulfonic acid-thionyl chloride failed to yield the expected trisulfonyl chloride because the substrate underwent an acid-catalyzed ring-opening reaction. This was confirmed by heating **6** with ethanolic hydrochloric acid to give N-phenyl-N′-thiobenzoylurea (**7**) (Scheme 2).

The cycloadduct **6**, by reaction with excess chlorosulfonic acid (8 molar equivalents) in thionyl chloride at room temperature, appeared to

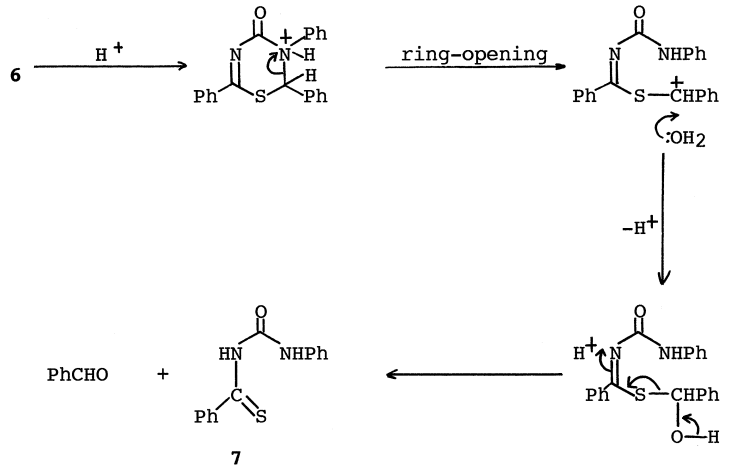


SCHEME 2

yield a mixture of the *bis*-sulfonyl chloride (**8**) and the chlorosulfonyl sulfonic acid (**9**) (Scheme 2). The same product mixture was obtained when **6** was heated under reflux with a large excess of chlorosulfonic acid (15 equivalents). This mixture of **8** and **9** was condensed with an excess of diethylamine to yield the *bis*-diethylsulfonamide (**10**) after two recrystallizations from ethanol.

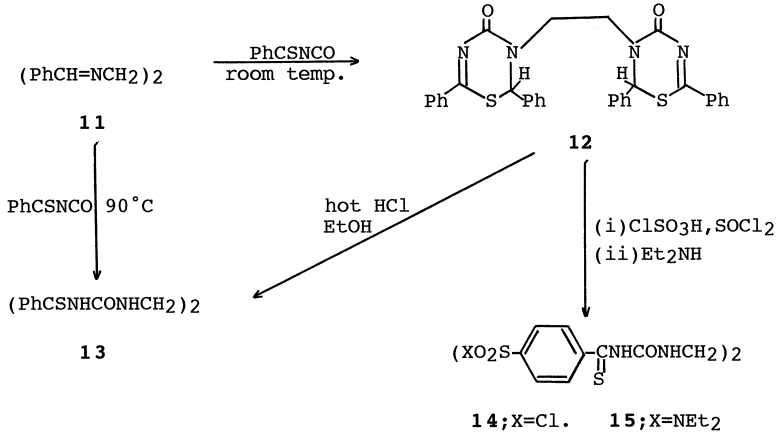
Reaction of N-phenyl-N′-thiobenzoylurea (**7**) with excess chlorosulfonic acid gave the same product mixture of **8** and **9**. The NMR spectral data indicated the presence of a *para*-sulfonyl group in one aromatic ring (AA′BB′ pattern) and a more complex aromatic proton resonance pattern in the other ring, possibly indicative of *ortho*-sulfonation. The broad resonance observed at ∂9.8 was reduced by D_2O treatment and is ascribed to the sulfonic acid group. The *ortho*-sulfonic acid (**9**) may have arisen from sulfonation of the thiol tautomer of **7** to give the S—SO_3H derivative. Suitable sulfonic and thiosulfonic acids can undergo acid-catalyzed migration of the sulfonic acid group into a neighboring aromatic nucleus, as was observed[8] in the chlorosulfonation of N-phenyl-N′-2-pyridylurea.

The acid-catalyzed ring-opening reaction of 2,3,6-triphenyl-2,3-dihydro-1,3,5-thiadiazin-4-one (**6**) to yield N-phenyl-N′-thiobenzoylurea (**7**) resembles the previously reported[7] ring-opening of 1, 6-diphenylhexahydro-*s*-triazine-2,4-dione to give N-(sulfonylphenyl)-N′-carbamoylurea by reaction with chlorosulfonic acid. The proposed mechanism for the acid-catalysed ring-opening of **6** is given in Scheme 3.



SCHEME 3

Thiobenzoyl isocyanate is reported[9] to react with dibenzylideneethylenediamine (**11**) to yield the *bis* (4 + 2) cycloadduct **12**, and the reaction was successfully repeated in xylene at room temperature. On the other hand reaction at 90°C resulted in the formation of a ring-opened product, namely N,N′-dithiobenzoylcarbamoylethylenediamine (**13**) (Scheme 4). The latter compound was also obtained when the cycloadduct **12** was heated with ethanolic hydrochloric acid, in an acid-catalyzed ring-opening directly analogous to the conversion of **6** into **7** (Scheme 2). Reaction of the cycloadduct **12** with excess chlorosulfonic acid (10 molar equivalents) in thionyl



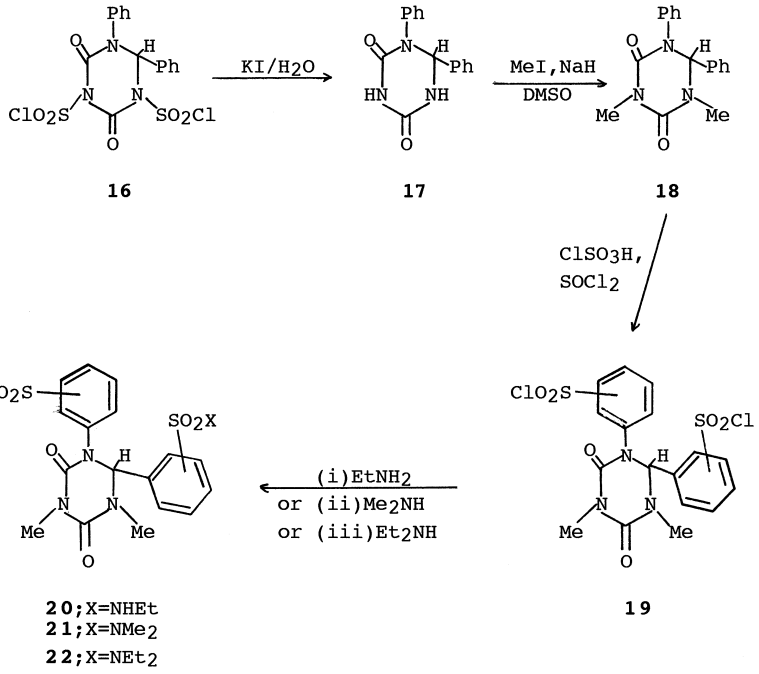
SCHEME 4

chloride at room temperature did not give the expected tetrachlorosulfonyl derivative but instead gave the ring-opened *bis*-sulfonyl chloride (**14**) (Scheme 4). This product gave a positive Beilstein test for chlorine and sulfur, and was condensed with diethylamine to yield the diethylsulfonamide (**15**). The mass spectra of the products **14** and **15** showed the relevant molecular ions, and the former also showed a fragment ion corresponding to the loss of one chlorosulfonyl moiety. Their NMR spectra showed the aromatic proton resonances as well-defined AA′BB′ patterns, indicative of *para*-substitution, and the correct aliphatic:aromatic proton ratio of 1:3. The formation of the *para*-substituted benzene rings in **14** suggests that chlorosulfonation of the aromatic nuclei is occurring prior to ring-opening, namely *before* formation of the thiocarbamoyl group, which would be expected to favor *ortho*-substitution via the intermediate thiosulfonic acid, as observed in the chlorosulfonation of **7** (Scheme 2).

Reaction of chlorosulfonyl isocyanate with benzylideneaniline gave 3,5-dichlorosulfonyl-1,6-diphenylhexahydro-*s*-triazine-2,4-dione (**16**) as described by Suschitzky and Bentley.[10] Subsequent treatment of this disulfonyl chloride with potassium iodide gave **17**, and then methylation afforded 3,5-dimethyl-1,6-diphenylhexa-hydro-*s*-triazine-2,4-dione (**18**). The latter, by reaction with excess chlorosulfonic acid (12 molar equivalents) in thionyl chloride at room temperature gave the dichlorosulfonyl derivative **19** in good yield. The use of less reagent (6 molar equivalents) afforded only a low yield of the product. The *bis*-sulfonyl chloride (**19**) was condensed with ethylamine, dimethylamine, and diethylamine to give the corresponding sulfonamides (**20–22**) (Scheme 5).

The NMR spectra of the derivatives showed the aromatic proton resonances as a complex pattern, possibly indicative of a mixture of meta- and *para*-sulfonation. Their EI mass spectra did not exhibit the molecular ions but only fragment ions corresponding in each case to loss of the relevant sulfonamido moiety. On the other hand the FAB mass spectrum of the diethylsulfonamide (**22**) showed the expected $M^+ + 1$ ion.

In conclusion, chlorosulfonation of the aldimine-isocyanate cycloadducts with chlorosulfonic acid is only successful when all the ring nitrogen atoms are substituted, as in compounds **2** and **18**. In the other substrates (**6, 12**, and **17**), acid-catalyzed ring-opening occurs, so the products are the chlorosulfonyl derivatives of the corresponding open-chain compounds. This is supported by the observation that 1,6-diphenylhexahydro-*s*-triazine-2,4-dione (**17**) is known[7] to react with chlorosulfonic acid to give N-(*para*-chlorosulfonylphenyl)-N′-carbamoylurea by an acid-catalyzed ring-opening reaction, whereas the corresponding N,N′-dimethyl derivative (**18**) formed the *bis*-sulfonyl chloride derivative (**19**) without ring-opening.



SCHEME 5

EXPERIMENTAL

Melting points were determined with a Gallenkamp electric apparatus and are uncorrected. IR spectra were recorded as nujol mulls using a Perkin Elmer 237 spectrophotometer. NMR spectra were measured with a Bruker AC 250 spectrometer and tetramethylsilane as internal standard and DMSO-d_6 as solvent, unless otherwise stated. Resonances reduced by D_2O treatment are indicated by an asterisk. EI mass spectra were obtained using a VG Micromass 16F spectrometer operating at 70 eV.

1,4-Diphenyldiazetidin-2-one (1)

Benzylideneaniline (10 g, 0.006 mmol) and sodium cyanate (5.38 g, 0.10 mmol) were added to glacial acetic acid (30 ml) and the mixture was stirred at 0°C for 2 h. The solvent was evaporated off under vacuum and the resultant solid was washed with ice-water and dried to give **1** (8.41 g, 68%), m.p. 224–225°C. (Found: C, 74.6; H, 5.7; N, 12.8. $C_{14}H_{12}N_2O$ requires C, 74.9; H, 5.4; N, 12.5%). IR: ν_{max} 3300 (NH), 1650 (C=O); 1600 (ArC=C) cm^{-1}. ^1H NMR: ∂9.0* (br s, 1H, NH), 7.4–7.1

(m, 10H, ArH), 6.7 (s, 1H, CH). ^{13}C NMR: ∂168 (C=O), 154 (CH), 128–117 (Ar). MS: 224 (M^+).

1,4-Diphenyl-3-methyldiazetidin-2-one (2)

The diphenyldiazetidinone (**1**) (5 g, 0.02 mmol) gradually was added to a stirred solution of sodium hydride (2 g) in dry DMF (20 ml) at room temperature. The mixture was heated on a water bath until a clear solution was obtained. Methyl iodide (3.76 g) was added with stirring and after 1 h the mixture was poured into water. The resultant solid was filtered off under suction and was recrystallized from ethanol to yield the N-methyl derivative (**2**) (1.3 g, 27%), m, p. 220–222°C. IR: ν_{max}1650 (C=O), 1600 (ArC=C) cm^{-1}. ^{1}H NMR: ∂7.4–7.2 (m, 10H, ArH), 6.9 (s, 1H, CH), 1.7 (s, 3H, Me). MS: 238 (M^+).

Chlorosulfonation of 1,4-Diphenyl-3-methyldiazetidin-2-one (2)

The phenylmethyldiazetidinone (**2**) (2.38 g, 0.01 mmol) gradally was added to a solution of chlorosulfonic acid (3.5 g, 0.03 mmol) in excess thionyl chloride (20 ml). The mixture was warmed on the water bath (50°C) for 3 h and poured onto ice-water (100 ml), with stirring. The resultant solid was filtered off and dried in vacuo to yield the disulfonyl chloride (**3**) (1.6 g, 37%), m.p. 180–182°C. The product showed positive Beilstein tests for Cl and S. IR: ν_{max} 1650 (C=O), 1360, 1180 (SO_2) cm^{-1}. ^{1}H NMR: ∂8.1–7.75 (m, 8H, ArH, AA′BB′ patterns), 6.8 (s, 1H, CH), 1.7 (s, 3H, Me). MS: 435 (M^+).

Condensation of (3) with (a) Dimethylamine

A solution of the *bis*-sulfonyl chloride (**3**) (2.2 g, 0.005 mmol) in cold acetone (20 ml) was reacted with excess dimethylamine (1.8 g, 0.04 mmol) at room temperature (for 8 h). The mixture was added to ice-water (100 ml): The solid precipitate was filtered off under vacuum and recrystallized from methanol to give the dimethylsulfonamide **4** (1.7 g, 70%), m.p. 215–217°C. IR: ν_{max}1650 (C=O) 1600 (ArC=C), 1365, 1180 (SO_2) cm^{-1}. ^{1}H NMR: ∂8.0–7.6 (m, 8H, ArH, AA′BB′ patterns), 2.9 (s, 12H, NMe_2), 1.8 (s, 3H, N—Me). MS: 484 (M^+).

Condensation of (3) with (b) Diethylamine

Treatment with excess amine similarly gave the corresponding diethylsulfonamide (**5**) (74%), m.p. 220–222°C. (Found: C, 56.5; H, 6.1; N, 10.5.

$C_{23}H_{34}N_4O_5S_2$ requires C, 56.7; H, 6.3; N, 10.4%). IR: ν_{max} 1650 (C=O), 1600 (ArC=C), 1370, 1180 (SO_2) cm^{-1}. ^1H NMR: ∂7.9–7.5 (m, 8H, ArH, AA′BB′ patterns), 3.3 (q, 8H, N$\underline{CH_2}$Me), 1.8 (s, 3H, N$\underline{Me}$), 1.2 (t, 12H, $NCH_2\underline{Me}$). MS: 540 (M^+).

2,3,6-Triphenyl-2,3-dihydro-1,3,5-thiadiazin-4-one (6)

A mixture of 2-phenylthiazoline-4,5-dione (2.0 g, 0.012 mmol) and benzylideneaniline (2.2 g, 0.012 mmol) was added to xylene (25 ml). The solution was stirred at room temperature (15 min), heated on the water bath (30 min) and cooled (0°C). The resultant precipitate was filtered off under suction and washed with ice-cold ethanol to give the cycloadduct **6** (2.18 g, 54%), m.p. 188–190°C (lit,[9] 193–194°C). (Found: C, 73.3; H, 4.7; N, 8.1. $C_{21}H_{16}N_2OS$ requires C, 73.2; H, 4.6; N, 8.1%). IR: ν_{max} 1660 (C=O), cm^{-1}. ^1H NMR ∂7.9–7.2 (m, 15H, ArH), 6.8 (s, 1H, CH). FAB (+) MS: 345 ($M^+ + 1$).

Reaction of the Cycloadduct 6 with Chlorosulfonic Acid

2,3,6-Triphenyl-2,3-dihydro-1,3,5-thiadiazin-4-one (**6**) (5 g, 0.014 mmol) was added gradually to a cold solution of chlorosulfonic acid (13 g, 0.112 mmol) in thionyl chloride (20 ml). The mixture was left at room temperature for 3 days and was poured onto ice-water (200 g). The solid precipitate was collected, washed with water, and dried in vacuo to give the sulfonyl chlorides **8** and **9** (3.2 g, 48%), m.p. 155–157°C. IR: ν_{max} 3300 (NH), 1660 (C=O) cm^{-1}. ^1H NMR: ∂9.8* (br, s, SO_3H), 9.0* (s, 2H, NH), 7.9–7.6 (m, 8H, ArH).

The *bis*-Diethylsulfonamide Derivative 10

The mixture of the sulfonyl chlorides (**8** and **9**) (2 g) was reacted with excess diethylamine in ethanol (20 ml) at room temperature (3 h). The reaction mixture was added to ice-water (100 ml) and the solid was filtered off under suction, washed with icewater, and recrystallized twice from ethanol to give the diethyl-sulfonamide **10** (13 g, 56%), m.p. 181–182°C. Found: C, 50. 4; H, 5.6; N, 10.4. $C_{22}H_{30}N_4O_5S$ requires C, 50. 2; H, 5.7; N, 10.6%). IR: ν_{max}3300 (NH), 1660 (C=O), 1360, 1180 (SO_2) cm^{-1}. ^1H NMR: ∂11.8*, 11.1* (2xbr s, 2H, NH), 8.1–7.6 (m, 8H, ArH), 3.0, 2.7 (2xq, 8H, $\underline{CH_2}$Me), 1.1, 1.0 (2xt, 12H, $CH_2\underline{Me}$). MS: 526 (M^+).

N-Phenyl-N′-thiobenzoylurea (7)

2,3,6-Triphenyl-2,3-dihydro-1,3,5-thiadiazin-4-one (**6**) (2 g) was heated on a water-bath with concentrated hydrochloric acid (5 ml) in methanol (20 ml) for 30 min. The clear yellow solution was evaporated under

reduced pressure and the solid residue was washed with ether to give the thiobenzoylurea (**7**) (0.43 g, 27%). (Found: C, 65. 4; H, 4.5; N, 10.6. $C_{14}H_{12}N_2OS$ requires C, 65.6; H, 4.7; N, 10.9%). ^{1}H NMR: ∂10.8*, 10.1* (2xbr s, 2H, NH), 8.1–7.6 (m, 10H, ArH). MS: 256 (M^+). Evaporation of the ether washings gave a residue of benzaldehyde, identified by formation of the 2,4-dinitrophenyl-hydrazone derivative.

Reaction of Dibenzylideneethylenediamine (11) with Thiobenzoyl Isocyanate

(a) At Room Temperature

A solution of dibenzylideneethylenediamine (**11**) (2 g, 0.0085 mmol) and thiobenzoyl isocyanate (3.1 g, 0.02 mmol) in xylene (30 ml) was stirred at room temperature (1 h). The solid precipitate was filtered off with suction, washed with ether, and dried to give the cycloadduct **12** (3.2 g, 67%), m.p. 228–230°C (lit.[9] 230–231°C). (Found: C, 68.5; H, 4.4; N, 9.6. $C_{32}H_{26}N_4O_2S_2$ requires C, 68. 3; H, 4.6; N 9.9%). IR: ν_{max} 1670 (C=O), 1620 (C=N), 1600 (ArC=C) cm^{-1}. ^{1}H NMR: ∂7.9–7.0 (m, 20H, ArH), 6.9 (s, 2H, CHN), 3.0–2.9 (q, 4H, CH_2). FAB (+) MS: 563 ($M^+ + 1$).

(b) At 90°C

Repetition of the reaction of dibenzylideneethylenediamine and thiobenzoyl isocyanate (2.3 equivalents) in xylene at 90°C (1 h) afforded N,N′-di (thiobenzoylcarbamoyl) ethylenediamine (**13**) (0.8 g, 54%), m.p. 238–240°C. (Found: C, 55.6; H, 4.4; N, 14.5. $C_{18}H_{18}N_4O_2S_2$ requires C, 55.9; H, 4.7; N, 14.5%). IR: ν_{max} 3200 (NH), 1660 (C=O) cm^{-1}. ^{1}H NMR ($CDCl_3$): ∂10.0*, 9.5* (2xbr s, 2H, NH), 8.1–7.4 (m, 10H, ArH), 3.88 (br t, 4H, CH_2). MS: 386 (M^+).

Reaction of the Cycloadduct 12 with Chlorosulfonic Acid

The cycloadduct **12** (5.0 g, 0.0122 mmol) was reacted with chlorosulfonic acid in thionyl chloride (20 ml) at room temperature (3 days). The solution was added to crushed ice (100 g) and the solid precipitate was filtered off under suction, washed with cold water, and dried in a vacuum desiccator to give the *bis*-sulfonyl chloride (**14**), (3.4 g, 44%), m.p. 147–150°C. IR: ν_{max} 3300, 1160 (SO_2) cm^{-1}. ^{1}H NMR: ∂10.6*, 9.2* (2xbr s, 4H, NH), 8.1–7.0 (m, 8H, ArH), 3.9 (t, 4H, CH_2). MS: 522, 518 (M^+).

The Diethylsulfonamide Derivative (15)

Condensation of the *bis*-sulfonyl chloride (**14**) with excess diethylamine (7 molar equivalents) in methanol at room temperature, addition of

ice-water, and recrystallization from ethanol, afforded the diethylsulfonamide **15** (1.64 g, 72%), m.p. 80–82°C. (Found: C, 47.2; H, 5.4; N, 12.6. $C_{26}H_{36}N_6O_6S_4$ requires C, 47.5; H, 5.5; N, 12.8%). ^{1}H NMR: ∂10.3*, 9.7* (2xbr, s 4H, NH), 7.9–7.2 (M, 8H, ArH, AA′BB′ pattern), 3.8 (t, 4H, CH_2CH_2), 3.0–2.7 (q, 8H, $N\underline{CH_2}Me$), 1.0 (t, 12H, $NCH_2\underline{Me}$) MS: 656 (M^+).

3,5-Dimethyl-1,6-diphenylhexahydro-*s*-triazine-2,4-dione (18)

Benzylideneaniline was reacted with chlorosulfonyl isocyanate as previously described[10] to give 3,5-dichlorosulfonyl-1,6-diphenyl hexahydro-*s*-triazine-2,4-dione (**16**). The cycloadduct, by treatment with aqueous potassium iodide, gave 1,6-diphenylhexahydro-*s*-triazine-2,4-dione (**17**), and subsequent methylation (methyl iodide-sodium hydride in DMF) afforded the dimethyl derivative (**18**) (58%), m.p. 114–115°C (lit.[10] 112°C). (Found: C, 69.1; H, 5.6; N, 14.0. $C_{17}H_{17}N_3O_2$ requires C, 69.1; H, 5.7; N, 14.2%). IR: ν_{max} 1680, 1670(C=O) cm^{-1}. ^{1}H NMR ($CDCl_3$): ∂7.4–7.1 (m, 10H, ArH), 6.1 (s, 1H, CH), 3.0, 2.9 (2xs, 6H, Me). MS: 295 (M^+).

Chlorosulfonation of 18

3,5-Dimethyl-1,6-diphenylhexahydro-*s*-triazine-2,4-dione (**18**) (5 g, 0.018 mmol) was added portionwise to a cold solution of chlorosulfonic acid (26 g, 0.23 mmol) in thionyl chloride (20 ml). The mixture was left at room temperature for 3 days, poured onto ice-water, and the solid precipitate collected, washed with water and dried in a vacuum desiccator (P_2O_5) to give the *bis*-sulfonyl chloride (**19**) (5.8 g, 65%), m.p. 82–8°C. IR: ν_{max}1680, 1670 (C=O), 1340, 1160 (SO_2) cm^{-1}. MS: 393 (M^+-SO_2Cl).

The *bis*-Ethylsulfonamide (20)

Prepared using ethylamine (5 molar equivalents): 73%, m.p. 86–89°C. (Found: C, 49.1; H, 5.2; N, 13.5. $C_{21}H_{27}N_5O_6S_2$ requires C, 49.5; H, 5.3; N, 13.7%). ^{1}H NMR: ∂10.1* (br s, 2H, NHEt), 7.7–7.1 (m, 8H, ArH), 6.1 (s, 1H, CH), 2.7–2.5 (q, 4H, $N\underline{CH_2}Me$), 1.1–1.0 (t, 6H, $NCH_2\underline{Me}$). MS: 402 (M^+-SO_2NH-Et).

The *bis*-Dimethylsulfonamide (21)

Prepared using dimethylamine: (59%), m.p. 88–90°C. (Found: C, 49.4; H, 5.1; N, 13.6. $C_{21}H_{27}N_5O_6S_2$ requires C, 49.5; H, 5.3; N, 13.7%).

^{1}H NMR: ∂7.8–7.1 (m, 8H, ArH), 6.1 (s, 1H, CH), 3.1, 3.2 (2xs, 12H, NMe_2). MS 402 (M^+-SO_2NMe_2).

The *bis*-Diethylsulfonamide (22)

Prepared using diethylamine: (68%), m.p. 91–93°C. (Found: C, 53.2; H, 6.2; N, 12.2. $C_{25}H_{35}N_5O_6S_2$ requires C, 53.1; H, 6.2; N, 12.4%). ^{1}H NMR: ∂7.7–7.2 (m, 8H, ArH), 6.3 (s, 1H, CH), 3.36, 3.37, (2xq, 8H, $N\underline{CH_2}Me$), 1.1–1.0 (t, 12H, $NCH_2\underline{Me}$). MS: 430 (M^+-SO_2NEt_2). FAB(+) MS: 566 ($M^+ + 1$).

REFERENCES

[1] R. J. Cremlyn, *Chlorosulfonic Acid: A Versatile Reagent* (Royal Society of Chemistry, Cambridge, 2002).
[2] R. J. Cremlyn, J. P. Bassin, S. Farouk, M. Potterton, and T. Mattu, *Phosphorus, Sulfur, and Silicon*, **73,** 107 (1992).
[3] R. J. Cremlyn, R. M. Ellam, S. Farouk, S. Graham, and A. Williams, *Phosphorus, Sulfur, and Silicon*, **122,** 87 (1997).
[4] R. J. Cremlyn, R. M. Ellam, and S. Farouk, *Phosphorus, Sulfur, and Silicon*, **161,** 213 (2000).
[5] S. Farouk, Ph.D. Thesis, University of Hertfordshire, (1994), p. 28.
[6] N. A. Lange, *J. Amer. Chem. Soc.*, **48,** 2440 (1926).
[7] R. J. Cremlyn, R. M. Ellam, and S. Farouk, *Pesticide Science*, **52,** 70 (1998).
[8] N. V. Badami, R. J. Cremlyn, and F. J. Swinbourne, *Aust. J. Chem.*, **30,** 1793 (1973).
[9] O. Tsuge and S. Kanema, *Bull. Chem. Soc. Jpn.*, **45,** 2877 (1972).
[10] H. Suschitzky and R. L. Bentley, *J. Chem. Soc. Perkin*, **1,** 1725 (1976).