Facile Synthesis of *N*-Sulfonylcyclothioureas in Water

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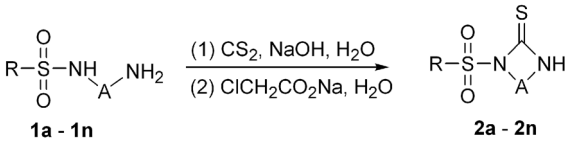
A sequential one-pot synthesis of *N*-sulfonylcyclothioureas from *N*-monosulfonyl diamines, CS_2 and chloroacetic acid at room temperature in water is described. In the absence of highly toxic thiophosgene and organic solvents, this method is environmentally benign. Simple reaction conditions, easy purification of the products, good yields and thioglycolic acid as the useful byproduct are also important attributes of this methodology. The plausible mechanism including tandem reactions is proposed.

Keywords sequential one-pot synthesis, *N*-sulfonylcyclothiourea, sulfonamides, synthetic methods, aqueous reaction, tandem reactions

Introduction

Thioureas play important roles in medicinal chemistry, synthetic chemistry, supramolecular chemistry and material chemistry.[1] As a kind of derivatives of thioureas, *N*-sulfonylcyclothioureas are also finding many applications, with examples including drug cores, protected *α*,*β*-diamino acids and organic synthesis.[2] The reaction of sulfonyl chlorides with cyclothioureas is the general synthetic method for *N*-sulfonylcyclothioureas.[3] To prepare cyclothioureas, diamines are commonly thioamidated by highly toxic thiophosgene.[4] Besides, CS_2 was reported as thioamidation agent of diamines in a few literatures.[5] Another route to synthesize *N*-sulfonylcyclothioureas is through the reaction of *N*-sulfonyldiamine and thiophosgene, which suffers from the drawbacks of low yield and the use of thiophosgene.[2a] The alternative synthetic method for *N*-sulfonylcyclothioureas is achieved via sulfonyl thioisocyanate,[6] which is prepared from sulfonamide and CS_2 in the presence of $SOCl_2$ or $COCl_2$.[7] Almost all of the above reactions are conducted in organic or aqueous organic solvents. Organic reactions in or on water have attracted the attention of chemists for many years.[8] Recently, the synthesis of thiourea derivatives from amines and CS_2 in the presence of sodium hydroxide in water at 100 ℃ was investigated.[9] Meanwhile, we reported that reactions of aminocalixarenes with CS_2, reactions of diamines and CS_2 and trisulfonamides, in the presence of $ClCH_2CO_2H$ in aqueous media afforded calixarenes and macrocycles bearing thiourea moieties, respectively.[10] Herein, a sequential one-pot synthesis of *N*-sulfonylcyclothioureas (**2a**—**n**) from *N*-monosulfonyl diamines (**1a**—1**n**), CS_2 and chloroacetic acid in water at room temperature is proposed (Scheme 1).

Scheme 1 Conversion of *N*-monosulfonyl diamine to *N*-sulfonylcyclothioureas



1a - 1n **2a - 2n**

R = C_6H_5, 2-MeC_6H_4, 3-$NO_2C_6H_4$, 4-MeC_6H_4, 4-ClC_6H_4, 4-FC_6H_4, 4-MeCONHC_6H_4, Me; A=$(CH_2)_2$, $(CH_2)_3$, $(CH_2)_6$, 1,2-C_6H_4

Experimental

Instruments

The melting points were obtained on a Laboratory Devices X-4 melting apparatus and are uncorrected. IR spectra were determined with a Perkin-Elmer 1600 spectrophotometer. The ^{1}H NMR spectra were determined in $CDCl_3$ or DMSO-d_6 with a Bruker AVANCE III 400 spectrometer operating at 400 MHz. The ^{13}C NMR spectra were determined in $CDCl_3$, DMSO-d_6 or acetone-d_6 with a Bruker AVANCE III 400 spectrometer operating at 100 MHz. MS (ESI) data were obtained on the Thermo Fisher LCQ Advantage MAX apparatus (LC/MS). HRMS data were obtained on Bruker microOTOF-Q II instrument. Thin layer chromatography was carried out using Merck silica gel GF254 plates. All reagents were purchased from commercial suppliers and used after standard procedure of purification.

Starting materials *N*-Monosulfonyl diamines (**1**) were prepared from corresponding diamines and sulfonyl chlorides by the appropriate reported procedure.[11]

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Typical procedure for the preparation of *N*-sulfonylcyclothioureas (2)

1-Phenylsulfonylimidazolidine-2-thione (2a) To a stirred suspension of *N*-phenylsulfonyl ethylenamine (**1a**, 0.30 g, 1.5 mmol) in water (10 mL) was added sodium hydroxide (0.12 g, 3.0 mmol) and carbon disulfide (0.15 g, 2.0 mmol) at room temperature. After 5 h, sodium chloroacetate (0.23 g, 2.0 mmol) was added and the reaction mixture was stirred overnight. The solid was filtered, washed with water and hot ethyl acetate, dried to give **2a** (0.24 g, 67% yield). White solid; m.p. 182—183 ℃; ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 9.54 (br s, 1H), 8.03 (d, J=8.0 Hz, 2H), 7.74 (t, J=7.2 Hz, 1H), 7.62 (t, J=7.8 Hz, 2H), 4.23 (t, J=8.6 Hz, 2H), 3.54 (t, J=8.6Hz, 2H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 179.16, 138.34, 134.40, 129.28 (2C), 128.83 (2C), 49.66, 41.83; IR (KBr) v: 3197, 1542, 1461, 1447, 1372, 1221, 1171, 1095, 1043, 721, 682, 603, 569 cm^{-1}; MS (ESI) *m/z*: 243 (M+H)$^+$. Anal. calcd for $C_9H_{10}N_2O_2S_2$: C 44.61, H 4.16, N 11.56; found C 44.52, H 4.29, N 11.40.

1-(2-Methylphenylsulfonyl)imidazolidine-2-thione (2b) White solid, 61% yield; m.p. 226—227 ℃; ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 9.54 (s, 1H), 8.01—7.99 (m, 1H), 7.60—7.56 (m, 1H), 7.43—7.40 (m, 1H), 4.29—4.25 (m, 2H), 3.65—3.60 (m, 2H), 2.54 (s, 3H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 179.06, 137.93, 137.55, 134.03, 132.72, 131.68, 126.45, 48.67, 41.96, 20.24; IR (KBr) v: 3335, 2985, 2971, 2093, 1594, 1520, 1350, 1158, 1040, 959, 774, 693, 665, 608, 540 cm^{-1}; MS (ESI) *m/z*: 257 (M + H)$^+$. Anal. calcd for $C_{10}H_{12}N_2O_2S_2$: C 46.85, H 4.72, N 10.93; found C 46.63, H 4.80, N 10.97.

1-(3-Nitrophenylsulfonyl)imidazolidine-2-thione (2c) Yellow solid, 66% yield; m.p. 220—221 ℃; ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 8.75 (s, 1H), 8.57 (d, J=8.4 Hz, 1H), 8.48 (d, J=7.6 Hz, 1H), 7.93 (t, J=8.2 Hz, 1H), 4.30 (t, J=8.8 Hz, 2H), 3.57 (t, J=8.8 Hz, 2H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 178.64, 147.78, 139.60, 134.82, 131.32, 129.01, 124.14, 49.68, 42.06; IR (KBr) v: 3399, 1515, 1474, 1366, 1172, 1126, 1086, 1033, 879, 674, 613, 544 cm^{-1}; MS (ESI) *m/z*: 288 (M+H)$^+$. HRMS (ESI) calcd for $C_9H_8N_3O_4S_2$ (M−H)$^-$ 285.9952, found 285.9961.

1-(4-Methylphenylsulfonyl)imidazolidine-2-thione (2d) White solid, 58% yield; m.p. 224—225 ℃ (Lit.[6] 226—227 ℃); ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 9.46 (br s, 1H), 7.91 (d, J=8.0 Hz, 2H), 7.42 (d, J=8.4 Hz, 2H), 4.20 (t, J=8.6 Hz, 2H), 3.52 (t, J=8.8 Hz, 2H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 179.23, 145.04, 135.37, 129.71 (2C), 128.92 (2C), 49.62, 41.74, 21.57; IR (KBr) v: 3341, 1594, 1525, 1472, 1349, 1204, 1157, 1085, 1040, 813, 665, 595, 538 cm^{-1}; MS (ESI) *m/z*: 257 (M+H)$^+$.

1-(4-Chlorophenylsulfonyl)imidazolidine-2-thione (2e) White solid, 40% yield; m.p. 207—209 ℃; ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 8.07 (d, J=8.4 Hz, 2H), 7.52 (d, J=8.4 Hz, 2H), 6.28 (br s, 1H), 4.31 (t, J=8.6 Hz, 2H), 3.66 (t, J=8.6 Hz, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 180.49, 140.92, 135.75, 130.49 (2C), 129.03 (2C), 49.46, 41.65; IR (KBr) v: 3380, 1523, 1470, 1394, 1340, 1218, 1172, 1087, 1037, 828, 762, 631, 587, 545 cm^{-1}; MS (ESI) *m/z*: 277 [M+H]$^+$. HRMS (ESI) calcd for $C_9H_9ClN_2O_2S_2Na$ (M + Na)$^+$ 298.9686, found 298.9684.

1-(4-Fluorophenylsulfonyl)imidazolidine-2-thione (2f) White solid, 73% yield; m.p. 193—194 ℃; ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 9.60 (s, 1H), 8.13—8.10 (m, 2H), 7.47 (t, J=8.8 Hz, 2H), 4.23 (t, J=8.6 Hz, 2H), 3.55 (t, J=8.6 Hz, 2H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 179.01, 165.55 (J=251.5 Hz), 134.58 (J=2.8 Hz), 132.20 (J=9.8 Hz, 2C), 116.47 (J=22.7 Hz, 2C), 49.61, 41.84; IR (KBr) v: 3188, 1592, 1539, 1484, 1372, 1292, 1217, 1174, 1091, 1043, 833, 669, 595, 550, 539 cm^{-1}; MS (ESI) *m/z*: 261 (M+H)$^+$. HRMS (ESI) calcd for $C_9H_9FN_2O_2S_2Na$ (M + Na)$^+$ 282.9982, found 282.9985.

(3a*R*,7a*R*)-Octahydro-1-(4-methylphenylsulfonyl)-*2H*-benzimidazole-2-thione (2g) White solid, 75% yield; m.p. 117—119 ℃; ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 7.95 (d, J=8.4 Hz, 2H), 7.32 (d, J=8.4 Hz, 2H), 6.84 (br s, 1H), 3.53—3.47 (m, 1H), 3.34—3.28 (m, 1H), 2.93—2.89 (m, 1H), 2.44 (s, 3H), 2.05—1.94 (m, 2H), 1.85—1.78 (m, 2H), 1.44—1.34 (m, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 183.65, 145.02, 134.34, 129.28 (2C), 128.98 (2C), 70.06, 61.76, 31.09, 28.86, 24.32, 23.50, 21.71; IR (KBr) v: 3334, 2942, 2665, 1597, 1461, 1356, 1171, 1082, 813, 715, 659, 596, 547, 527 cm^{-1}; MS (ESI) *m/z*: 311 (M+H)$^+$. Anal. calcd for $C_{14}H_{18}N_2O_2S_2$: C 54.17, H 5.84, N 9.02; found C 54.25, H 5.84, N 9.01.

1-Phenylsulfonylhexahydropyrimidine-2-thione (2h) White solid, 78% yield; m.p. 155—157 ℃; ^{1}H NMR (Acetone-d_6, 400 MHz) δ: 8.15 (br s, 1H), 7.97 (d, J=7.6 Hz, 2H), 7.63 (t, J=7.6 Hz, 1H), 7.55 (t, J=7.6 Hz, 2H), 4.17—4.14 (m, 2H), 3.38—3.34 (m, 2H), 2.20—2.14 (m, 2H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 176.37, 133.34, 129.75, 129.06 (2C), 128.14 (2C), 46.68, 41.67, 21.69; IR (KBr) v: 3180, 3054, 1528, 1449, 1420, 1322, 1246, 1164, 948, 858, 764, 688, 653, 568 cm^{-1}; HRMS (ESI) calcd for $C_{10}H_{12}N_2O_2S_2Na$ (M + Na)$^+$ 279.0232, found 279.0229.

1-(4-Methylphenylsulfonyl)hexahydropyrimidine-2-thione (2i) White solid, 80% yield; m.p. 191—193 ℃ (Lit.[6] 191—193.5 ℃); ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 7.86 (d, J=8.4 Hz, 2H), 7.29 (d, J=8.4 Hz, 2H), 6.85 (br s, 1H), 4.15—4.12 (m, 2H), 3.33—3.30 (m, 2H), 2.42 (s, 3H), 2.18—1.12 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 178.40, 144.37, 136.79, 129.08 (2C), 128.78 (2C), 45.99, 42.09, 21.66, 21.58; IR (KBr) v: 3180, 3047, 1555, 1485, 1418, 1339, 1262, 1174, 1104, 965, 892, 806, 745, 674, 619, 547, 532 cm^{-1}; MS (ESI) *m/z*: 271 (M+H)$^+$.

1-(4-Methylphenylsulfonyl)-1,3-diazonane-2-thione (2j) Yellow oil, 75% yield; ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 7.75 (d, J=8.0 Hz, 2H), 7.32 (d, J=8.0

Hz, 2H), 4.58 (t, J=4.0 Hz, 1H), 3.49—3.46 (m, 2H), 2.95—2.93 (m, 2H), 2.44 (s, 3H), 1.65—1.61 (m, 2H), 1.50—1.45 (m, 2H), 1.36—1.31 (m, 4H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 182.98, 143.42, 137.09, 129.72 (2C), 127.09 (2C), 44.88, 42.97, 29.72, 29.39, 26.02, 25.68, 21.49; IR (KBr) v: 3294, 2932, 2859, 2101, 1598, 1324, 1158, 813, 664, 550 cm^{-1}; HRMS (ESI$^+$) calcd for $C_{14}H_{20}N_2O_2S_2Na$ $(M+Na)^+$ 335.0858, found 335.0859.

1-Methysulfonyl-1,3-dihydro-2*H*-benzimidazole-2-thione (2k) White solid, 91% yield; m.p. 162—163 ℃; ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 13.53 (br s, 1H), 7.81 (d, J = 8.0 Hz, 1H), 7.34—7.30 (m, 1H), 7.27—7.22 (m, 2H), 3.92 (s, 3H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 169.41, 131.42, 131.37, 125.57, 123.89, 113.87, 110.63, 41.44; IR (KBr) v: 3096, 3019, 2923, 1619, 1510, 1450, 1414, 1364, 1296, 1262, 1171, 1046, 971, 753, 618, 529 cm^{-1}; MS (ESI) m/z: 229 $(M+H)^+$. HRMS (ESI) calcd for $C_8H_8N_2O_2S_2Na$ $(M+Na)^+$ 250.9919, found 250.9926.

1-Phenylsulfonyl-1,3-dihydro-2*H*-benzimidazole-2-thione (2l White solid, 93% yield; m.p. 165—167 ℃; ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 13.42 (br s, 1H), 8.11—8.09 (m, 2H), 8.05—8.03(m, 1H), 7.82—7.79 (m, 2H), 7.69—7.65 (m, 1H), 7.36—7.31 (m, 2H), 7.21—7.19 (m, 1H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 169.09, 136.98, 135.73, 131.66, 131.21, 129.83 (2C), 128.71 (2C), 126.01, 124.16, 114.01, 110.72; IR (KBr) v: 3036, 2962, 2920, 1591, 1505, 1450, 1382, 1292, 1260, 1197, 1152, 1085, 1040, 746, 727, 692, 663, 583, 545 cm^{-1}; MS (ESI) m/z: 289 $(M+H)^+$. Anal. calcd for $C_{13}H_{10}N_2O_2S_2$: C 53.77, H 3.47, N 9.65; found C 53.32, H 3.60, N 9.68.

1-(4-Methylphenylsulfonyl)-1,3-dihydro-2*H*-benzimidazole-2-thione (2m) White crystal, 75% yield; m.p. 156—157 ℃; ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 13.37 (br s, 1H), 8.02—7.99 (m, 1H), 7.96 (d, J=8.4 Hz, 2H), 7.45 (d, J=8.4 Hz, 2H), 7.35—7.29 (m, 2H), 7.19—7.17 (m, 1H), 2.39 (s, 3H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 169.08, 146.73, 134.05, 131.64, 131.17, 130.24 (2C), 128.77 (2C), 125.95, 124.12, 114.02, 110.67, 21.66; IR (KBr) v: 3147, 3105, 2985, 1596, 1494, 1436, 1378, 1295, 1196, 1169, 1087, 810, 754, 675, 578, 547 cm^{-1}; MS (ESI) m/z: 305 $(M+H)^+$. Anal. calcd for $C_{14}H_{12}N_2O_2S_2$: C 55.24, H 3.97, N 9.20; found C 54.96, H 4.08, N 9.21.

1-(4-Acetylaminophenylsulfonyl)-1,3-dihydro-2*H*-benzimidazole-2-thione (2n) White solid, 71% yield; m.p. 189—191 ℃; ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 10.48 (s, 1H), 8.01 (d, J=8.8 Hz, 2H), 7.98—7.96 (m, 1H), 7.78 (d, J=8.8 Hz, 2H), 7.31—7.24 (m, 2H), 7.17—7.15 (m, 1H), 2.08 (s, 3H); ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 169.79, 169.18, 145.57, 132.85, 131.56, 130.33 (2C), 130.22, 125.60, 123.65, 118.71 (2C), 113.88, 111.02, 24.63; IR (KBr) v: 3464, 3389, 3316, 1673, 1587, 1537, 1446, 1404, 1320, 1262, 1200, 1168, 1092, 1047, 841, 747, 726, 660, 613, 578, 550 cm^{-1}; MS (ESI) m/z: 348 $(M+H)^+$. HRMS (ESI) calcd for $C_{15}H_{13}N_3O_3S_2Na$ $(M+Na)^+$ 370.0291, found 370.0291.

Results and discussion

Initially we began our investigation by choosing *N*-tosylethylenediamine (**1d**) as the model substrate, which reacted with CS_2 and chloroacetate in sequence to afford 1-tosylimidazoline-2-thione (**2d**). The reaction time of the first step was determined by the color change of the reaction mixtures. This solution or nearly apparent suspension turned yellow completely 5 h after the CS_2 was dropped in, which indicated the formation of the corresponding dithiocarbamate. The reaction time of the second step was determined by the fully precipitating of the products and the color change of the reaction solution. The other reaction conditions, such as the base, the temperature and the other halide reagents were screened (Table 1). The results show the yields did not increase remarkably with the rise of the temperature. Hence, room temperature (20 ℃) is appropriate for the reaction. The bases can be either hydroxides, such as NaOH and KOH, or carbonates. The difference of them is that the precipitated products were more pure when the hydroxides were used. MeI was observed inferior to chloroacetic acid. Moreover, other iodide, such as KI, did not catalyze the reaction efficiently.

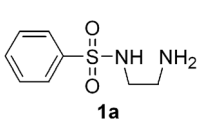
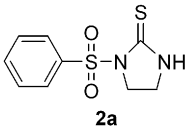
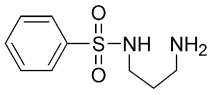
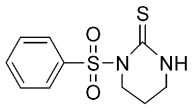
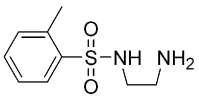
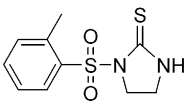
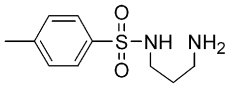
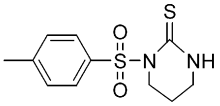
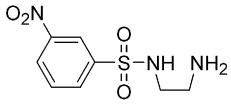
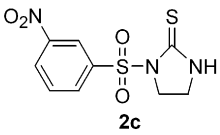
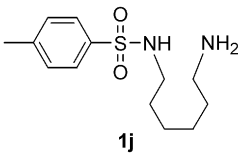
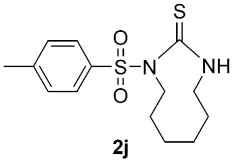
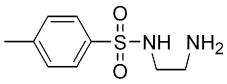
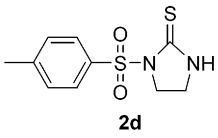
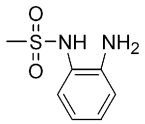
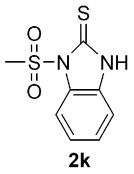
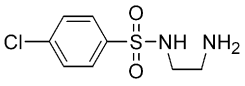
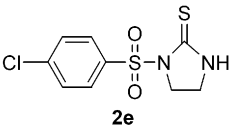
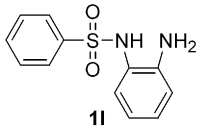
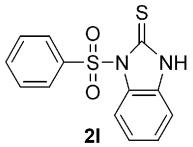
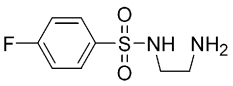
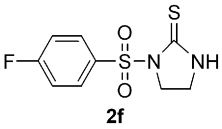
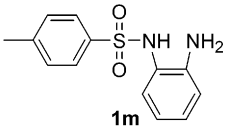
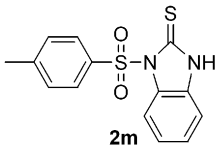
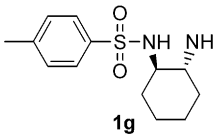
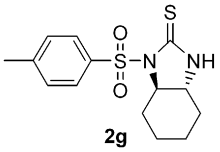
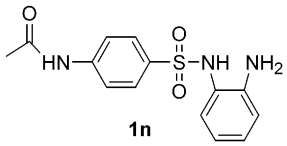
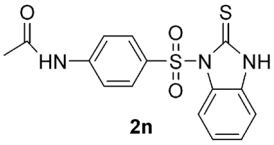
Table 1 Optimization of the reaction conditions

Entry	Temp./℃	Base[a]	Halide[b]	Yield[c]/%
1	20	KOH	$ClCH_2CO_2K$	57
2	50	KOH	$ClCH_2CO_2K$	63
3	20	NaOH	$ClCH_2CO_2Na$	58
4	20	Na_2CO_3	$ClCH_2CO_2Na$	51
5	20	KOH	MeI	11
6	40	KOH	MeI	16
7	20	KOH	$ClCH_2CO_2K$, KI 4 mol%	58
8	20	KOH	$ClCH_2CO_2K$, KI 8 mol%	60

[a] 2 equiv. [b] 1.3 equiv. [c] Isolated yield.

The scope of the reaction was investigated (Table 2). Most of *N*-monosulfonyl diamines can be cyclized steadily to the corresponding *N*-sulfonylcyclothioureas in good to excellent yields. The products except **2j** (obtained as viscous yellow oil) were white or yellow precipitates. The pure products were obtained only by suction filtration and washing or recrystallization with suitable solvents. In the substrates, some *N*-sulfonylaryldiamines could give excellent yields (Entries 11, 12), while *N*-sulfonylalkyldiamines often gave lower yields (Entries 1—7). The reaction of *N*-(3-aminopropyl)-phenylsulfonamide (**1h**), *N*-(3-aminopropyl)-4-methylbenzenesulfonamide (**1i**) and *N*-(6-aminohexyl)-4-methylbenzenesulfonamide (**1j**) with carbon disulfide also afforded good yields (Entries 8—10). Nitro and

Table 2 The scope of the reactions

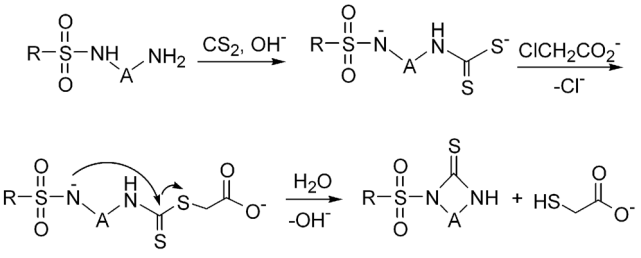
Entry	Substrate	Product	Yield[a]/%	Entry	Substrate	Product	Yield[a]/%
1	 **1a**	 **2a**	67	8	 **1h**	 **2h**	78
2	 **1b**	 **2b**	61	9	 **1i**	 **2i**	80
3	 **1c**	 **2c**	66	10	 **1j**	 **2j**	75
4	 **1d**	 **2d**	58	11	 **1k**	 **2k**	91
5	 **1e**	 **2e**	40	12	 **1l**	 **2l**	93
6	 **1f**	 **2f**	73	13	 **1m**	 **2m**	75
7	 **1g**	 **2g**	75	14	 **1n**	 **2n**	71

[a] Isolated yield.

acetamido groups on the benzene ring did not affect the cyclization (Entries 3, 14). Furthermore, *N*-tosyl-(1*R*,2*R*)-diaminocyclohexane gave the corresponding chiral product exclusively (Entry 7).

The plausible mechanism of the reactions is shown in Scheme 2. Three steps are involved in the reactions. Nuleophilic addition of *N*-monosulfonyl diamine to CS_2 in water provided *N*-sulfoaminoethyl dithiocarbamate, which is a nucleophile in the second step. Then the intramolecular nuleophilic substitution of sulfonamide anion and dithiocarbamate occurs in the third step. Thioglycolic acid was recovered by acidation, extraction of the remained filtrate and fractionation under reduced pressure according to the reported procedure.[12] This operation not only produced thioglycolic acid, an important chemical,[13] as another product, but also gave the evidence of the third step. The second and third step is tandem process. Therefore, all the transformation is sequential one-pot tandem reactions.

Scheme 2 Plausible mechanism of the reactions



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Conclusions

In summary, a sequential one-pot synthesis of *N*-sulfonylcyclothioureas from *N*-monosulfonyl diamines and CS_2 in water was developed. In this protocol, a variety of *N*-monosulfonyl diamines were converted to the cyclization products with no need of heating, highly toxic thiophosgene and organic solvents. The products are easy to isolate and purify as well. Further applications of this protocol are in progress in our laboratory.

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