A NOVEL TRANSFORMATION FROM 5-ARYL-4,4-DIMETHYL-2-PHENYLISOXAZOLIDINE-3-THIONES TO 4-ARYL-3,3-DIMETHYL-2-PHENYLIMINOTHIETHANES

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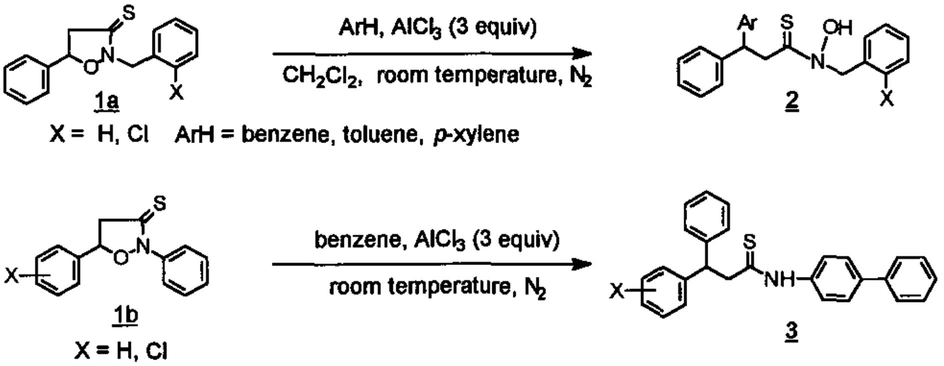
Abstract - Treatment of 5-aryl-4,4-dimethyl-2-phenylisoxazolidine-3-thiones with trimethylsilyl iodide (6 molar equiv) in the presence of zinc iodide (2 molar equiv) in chloroform at 50 °C under nitrogen atmosphere gave 4-aryl-3,3-dimethyl-2-(*N*-phenylimino)thiethanes in good to moderate yields.

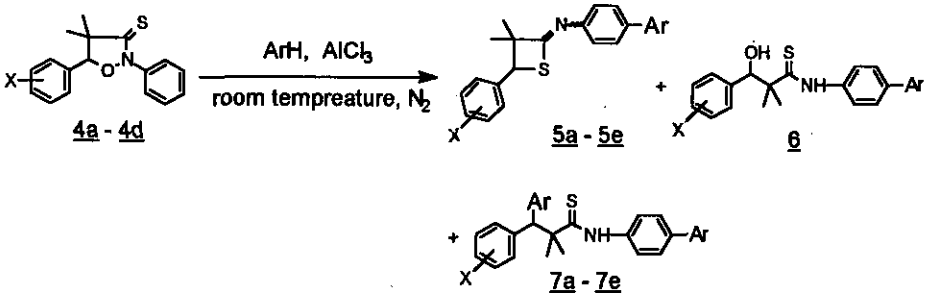
Previously we have shown that 2-benzyl-5-phenylisoxazolidine-3-thiones (1a) can be utilized as starting materials for the synthesis of 3-aryl-*N*-benzyl-3-phenylpropanothiohydroxamic acids (2),[1] which have been known as a class of compounds having biological activities such as insecticides[2] and antibiotics[3] or acting as excellent metal chelators.[4] Analogous reactions of 5-aryl-2-phenylisoxazolidine-3-thiones (1b) in benzene under the same conditions as with the reactions of 1a afforded 3-aryl-*N*-biphenylyl-3-phenylpropanothioamides (3) in good yields (Scheme 1).[5]

Scheme 1



However, similar treatment of 4,4-dimethyl-2,5-diphenylisoxazolidine-3-thione (4a, X = H) in the presence of anhydrous $AlCl_3$ (2 molar equiv) under the same conditions as with the reactions of 1b gave 2-[*N*-(*p*-biphenylylimino)]-3,3-dimethyl-4-phenylthiethane (5a, X = H, Ar = C_6H_5), *N*-(*p*-biphenylyl)-2,2-dimethyl-3-hydroxy-3-phenylpropanothioamide (6, X = H, Ar = C_6H_5) and *N*-(*p*-biphenylyl)-2,2-dimethyl-3,3-diphenyl-propanothioamide (7a, X = H, Ar = C_6H_5) in 8%, 22% and 16% yields, respectively in addition to 53% recovery of unreacted starting material (4a) (Scheme 2). However, the same reaction in the presence of anhydrous $AlCl_3$ (6 molar equiv) at reflux gave two compounds (5a) and (7a) in 45% and 15% yields, respectively. Table 1 shows the summary of the reaction conditions and yields of 4-aryl-2-[*N*-(*p*-biphenylylimino)]-3,3-dimethylthiethanes (5a - 5e) and 3,3-diaryl-*N*-(*p*-biphenylyl)-2,2-dimethylpropanothioamides (7a - 7e), and analytical and spectroscopic data of compounds (5a - 5e) and (7a - 7e) are summarized in Table 2 and Table 3, respectively.

Scheme 2



4	X	5 and 7	X	Ar
a	H	a	H	C_6H_5
b	2-Cl	b	H	$4\text{-}MeC_6H_4$
c	3-Cl	c	2-Cl	C_6H_5
d	4-Cl	d	3-Cl	C_6H_5
e	2-Br	e	4-Cl	C_6H_5
f	4-Br			
g	2-Me			
h	3-Me			
i	4-Me			

Table 1. Reaction Conditions and Yields of 4-Aryl-2-[*N*-(*p*-biphenylylimino)]-3,3-dimethylthiethanes (5a - 5e) and 3,3-Diaryl-*N*-(*p*-biphenylyl)-2,2-dimethylpropanothioamides (7a - 7e)

Compound (mmol)	$AlCl_3$ (mmol)	ArH[a]	Time (min)	Product	Yield (%)	Product	Yield (%)
4a (1.96)	12.3	benzene	30	5a	45	7a	15
4a (0.794)	4.84	toluene	5	5b	28	7b	42
4b (0.988)	6.03	benzene	30	5c	26	7c	61
4c (0.544)	3.32	benzene	30	5d	27	7d	34
4d (0.912)	5.79	benzene	30	5e	19	7e	38

[a] ArH: 30 ml.

Table 2. Analytical, Ir, and ^{1}H Nmr Data of 4-Aryl-2-[*N*-(*p*-biphenylylimino)]-3,3-dimethylthiethanes (5)

Compound	mp (°C)	Ir (film) (υ, cm^{-1})	^{1}H nmr (CDCl$_3$) (δ, ppm)	Molecular Formula	Calcd/Found % C	H	N	S
5a	liquid	1660	1.00 (3H, s, Me), 1.61 (3H, s, Me), 4.62 (1H, s, $C\underline{H}C_6H_5$), 7.00 - 7.78(14H, m, ArH)	$C_{23}H_{21}NS$	80.43 80.34	6.16 6.09	4.08 4.05	9.33 9.29
5b	liquid	1660	1.07 (3H, s, Me), 1.70 (3H, s, Me), 2.41 (3H, s, $C\underline{H}_3C_6H_4$), 4.68 (1H, s, $C\underline{H}C_6H_5$), 7.16 - 7.63 (13H, m, ArH)	$C_{24}H_{23}NS$	80.62 80.49	6.48 6.41	3.92 3.89	8.97 8.81
5c	109 - 110 (MeCN)	1670[a]	1.04 (3H, s, Me), 1.86 (3H, s, Me), 5.22 (1H, s, $C\underline{H}C_6H_4Cl$), 7.22 - 7.91 (13H, m, ArH)	$C_{23}H_{20}NClS$	73.10 73.05	5.33 5.25	3.71 3.68	8.48 8.39
5d	liquid	1665	1.05 (3H, s, Me), 1.67 (3H, s, Me), 4.67 (1H, s, $C\underline{H}C_6H_4Cl$), 7.10 - 7.91 (13H, m, ArH)	$C_{23}H_{20}NClS$	73.10 73.03	5.33 5.29	3.71 3.66	8.48 8.35
5e	liquid	1658	1.00 (3H, s, Me), 1.66 (3H, s, Me), 4.61 (1H, s, $C\underline{H}C_6H_4Cl$), 6.91 - 8.13 (13H, m, ArH)	$C_{23}H_{20}NClS$	73.10 73.08	5.33 5.24	3.71 3.65	8.48 8.43

[a] KBr

Table 3. Analytical, Ir, and ^{1}H Nmr Data of *N*-(*p*-Biphenylyl)-3,3-diaryl-2,2-dimethylpropanothioamides (7)

Compound	mp (°C)	Ir (KBr) (υ, cm^{-1})	^{1}H Nmr (CDCl$_3$) (δ, ppm)	Molecular Formula	Calcd/Found % C	H	N	S
7a	184 - 185 (*n*-hexane)	3345	1.56 (6H, s, 2Me), 4.67 (1H, s, $C\underline{H}(C_6H_5)_2$) , 6.96-7.73 (19 H, m, ArH), 8.33 (1H, s, NH)	$C_{29}H_{27}NS$	82.61 82.54	6.46 6.39	3.32 3.28	7.60 7.54
7b	146 - 147 (*n*-hexane - EtOAc)	3320	1.60 (6H, s, 2Me), 2.37 (3H, s, Me), 2.43 (3H, s, Me), 4.72 (1H, s, $C\underline{H}C_6H_4(C_6H_4Me)$), 7.02-7.92 (17H, m, ArH), 8.55 (1H, s, NH)	$C_{30}H_{31}NS$	82.33 82.21	7.14 7.13	3.20 3.07	7.33 7.30
7c	206 - 207.5 (*n*-hexane - EtOAc)	3390	1.56 (3H, s, Me), 1.62 (3H, s, Me), 5.45 (1H, s, $C\underline{H}C_6H_5$), 7.04-7.95 (18H, m, ArH)	$C_{29}H_{26}NClS$	76.38 76.29	5.75 5.64	3.07 3.01	7.02 6.89
7d	190 - 192 (*n*-hexane - EtOAc)	3300	1.60 (6H, s, 2Me), 4.82 (1H, s, $C\underline{H}C_6H_5$), 7.09-7.78 (18H, m, ArH)	$C_{29}H_{26}ClNS$	76.38 76.32	5.75 5.69	3.07 3.05	7.02 6.97
7e	185 - 186 (*n*-hexane - EtOAc)	3300	1.60 (6H, s, 2Me), 4.83 (1H, s, $C\underline{H}C_6H_5$), 6.85-8.10 (18H, m, ArH), 8.58 (1H, s, NH)	$C_{29}H_{26}NClS$	76.38 76.29	5.75 5.61	3.07 3.03	7.02 7.01

The formation of 2-iminothiethanes (5) from isoxazolidine-3-thiones (4) albeit low yields suggests that compounds (4) with appropriate substituents at C-4 and C-5, and nitrogen atom can be utilized as potential starting materials for the syntheses of compounds (5) which have been synthesized by a limited number of methods: One method being utilized most widely so far is a [2 + 2] cycloaddition reaction between ketenimines and diarylthioketones,[6] which gives compounds (5) having two aryl groups at C-4. Only two diaryl thioketones, i.e. thiobenzophenone and thioxanthone, appear to be employed. Not only access to stable C,C-disubstituted ketenimines but also the dependence of the products on the nature of the *N*-substituent might narrow the usefulness of the cyclization reactions.[6] The other method involves the reaction of a carbanion generated at α position to the carbonyl group of β-lactone with phenyl isothiocyanate,[7] which may not be a useful method for lack of synthetic versatility in addition to relatively low yields. A photocyclization of *N*-alkylthiomethacrylamides reported recently might be a promising method to obtain compounds (5) with an alkyl group at C-4.[8] However, the scope of the reaction has not been explored much.

In order to improve the yields of compounds (5), compound (4a) was treated with various Lewis acids in different solvents, i.e. $EtAlCl_2$/toluene, N_2, reflux; $TiCl_4$/toluene, N_2, reflux; Et_3Al/n-hexane, N_2, 0 °C; Et_3B/*n*-hexane, N_2, room temperature; Et_2AlCN/toluene, N_2, room temperature. However, all of the reactions were very complicated and it was unsuccessful to isolate the desired compound. In the light of demethylation of aryl methyl ethers by trimethylsilyl iodide (TMSI),[9] compound (4a) was treated with TMSI in chloroform at 50 °C for 12 days. The reaction was quenched when no spot corresponding to 4a was observed on tlc (silica gel, $R_f = 0.65$, *n*-hexane/ethyl acetate = 10:1) and from the reaction mixture were isolated 2-iminothiethane (8a, X = H) as a major product (42%) and a trace amount of 3-hydroxypropanothioamide (9a, X = H). By addition of zinc iodide (ZnI_2), followed by TMSI, the reaction was completed in 6 days with the increased yield of 8a (X = H) in 67% along with a trace amount of 9a (X = H).

Other 2-iminothiethanes (8b - 8i) were obtained under the latter conditions and essentially no compounds (9) except for compounds (9c, X = 3-Cl), (9e, X = 2-Br) and (9f, X = 4-Br) were isolated (Scheme 3). The reaction conditions and yields of 2-iminothiethanes (8a - 8i) are collected in Table 4, and their analytical and spectroscopic data are summarized in Table 5.

Scheme 3

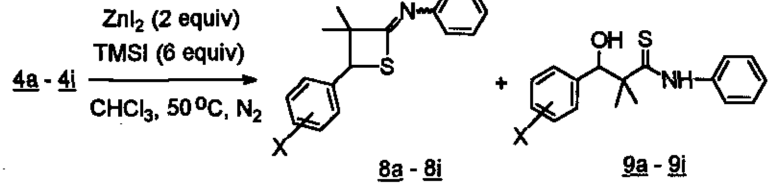


Table 4. Reaction Conditions and Yields of 4-Aryl-3,3-dimethyl-2-(*N*-phenylimino)thiethanes (8a - 8i)

Compound (mmol)		ZnI_2 (mmol)	TMSI (mmol)	Time (day)	Product	Yield (%)
4a	0.728	1.46	4.36	6	8a	67
4b	0.798	1.60	4.78	5.5	8b	61
4c	0.299	1.88	5.69	3.5	8c	29[a]
4d	0.789	1.60	4.78	3.5	8d	66
4e	0.685	1.44	4.36	3	8e	51[a]
4f	0.693	1.41	4.22	3	8f	53[a]
4g	0.846	1.69	5.06	3.5	8g	74
4h	0.756	1.57	4.92	4.5	8h	75
4i	0.982	1.97	5.90	3.5	8i	83

[a] 3-(3-Chlorophenyl)-2,2-dimethyl-3-hydroxy-*N*-phenyl- (9c, X = 3-Cl), 3-(2-bromophenyl)-2,2-dimethyl-3-hydroxy-*N*-phenyl- (9e, X = 2-Br), and 3-(4-bromophenyl)-2,2-dimethyl-3-hydroxy-*N*-phenylpropanothioamides (9f, X = 4-Br) were isolated in 36%, 29%, and 17% yields, respectively.

Reaction of compound (1b, X = H) under foregoing conditions gave a complex mixture, whereas that of *cis*-2,5-diphenyl-4-methylisoxazolidine-3-thione (10)[10] gave *trans*-3-methyl-4-phenyl-2-(*N*-phenylimino)-thiethane (11)[10] as a major product (58%). This result indicates that a substituent at C-4 of compounds (4) might play an important role either for the selective cleavage between O-N and O-C bonds at the initial stage of the reaction or for the stability of 2-iminothiethanes (8) without any substituent at C-3 which at present is uncertain.

Ir spectra of compounds (5, 8, and 11) showed a strong band assignable to C=N double bond in the range of 1651 - 1670 cm^{-1} which is close to the reported values, i.e. 1660[6-8] and 1680[6] cm^{-1}. Mass spectra of all 2-iminothiethanes prepared showed the corresponding molecular ion peak. The stereochemistry of compound (11) was determined on the basis of ^1H Nmr coupling constant $J_{3,4}$: A doublet at δ 4.39 ppm derived from a proton at C-4 by coupling with a proton at C-3 had $J_{3,4}$ = 4.6 Hz, which is in accord with $J_{3,4}$ = 4.5 Hz of an analogous compound, *trans*-4-alkyl-3-phenyl-2-(*N*-phenylimino)thiethane.[7] The stereochemical assignment was further supported by ^1H Nmr coupling constants $J_{3,4}$ = 4.4 Hz and $J_{3,4}$ = 8.1 Hz exhibited by *trans*- and *cis*-2-alkylimino-3,4-dialkylthiethanes, respectively.[8]

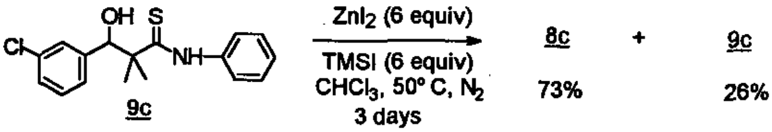
When compound (9c) was subjected under the same conditions as with the reaction of compound (4c) for 3 days, 2-iminothiethane (8c, X = 3-Cl) and unreacted compound (9c) were isolated in 73% and 26% yields, respectively (Scheme 4). This result indicates an intermediary of propanothioamides (9) for leading to 2-iminothiethanes (8), which in turn supports O-N bond cleavage at the initial reaction stage.

Table 5. Analytical, Ir, and ^{1}H Nmr data of 4-Aryl-3,3-dimethyl-2-(*N*-phenylimino)thiethanes (8)[a]

Compound	Ir (film) (ν, cm^{-1})	^{1}H Nmr (CDCl$_3$) (δ, ppm)	Molecular Formula	Calcd/Found % C	H	N	S
8a	1670	1.01 (3H, s, Me), 1.63 (3H, s, Me), 4.62 (1H, s, $C\underline{H}C_6H_5$), 7.04-7.48 (10H, m, ArH)	$C_{17}H_{17}NS$	76.36 76.24	6.41 6.39	5.24 5.17	11.99 11.89
8b	1654	1.00 (3H, s, Me), 1.79 (3H, s, Me), 5.01 (1H, s, $C\underline{H}C_6H_4Cl$), 7.00-7.52 (8H, m, ArH), 7.80 - 7.96 (1H, m, ArH)	$C_{17}H_{16}NClS$	67.65 67.53	5.34 5.26	4.64 4.59	10.62 10.58
8c	1656	0.98 (3H, s, Me), 1.60 (3H, s, Me), 4.54 (1H, s, $C\underline{H}C_6H_4Cl$), 6.89-7.59 (9H, m, ArH)	$C_{17}H_{16}NClS$	67.65 67.63	5.34 5.22	4.64 4.56	10.62 10.81
8d	1657	0.95 (3H, s, Me), 1.83 (3H, s, Me), 4.53 (1H, s, $C\underline{H}C_6H_4Cl$), 6.94-7.71 (9H, m, ArH)	$C_{17}H_{16}NClS$	67.65 67.51	5.34 5.28	4.64 4.51	10.62 10.55
8e	1654	0.96 (3H, s, Me), 1.83 (3H, s, Me), 5.03 (1H, s, $C\underline{H}C_6H_4Br$), 6.91-7.73 (8H, m, ArH), 7.77 - 8.12 (1H, m, ArH)	$C_{17}H_{16}NBrS$	58.96 58.87	4.66 4.51	4.04 4.06	9.26 9.15
8f	1651	0.95 (3H, s, Me), 1.59 (3H, s, Me), 4.51 (1H, s, $C\underline{H}C_6H_4Br$), 6.89-7.64 (9H, m, ArH)	$C_{17}H_{16}NBrS$	58.96 58.88	4.66 4.63	4.04 3.96	9.26 9.11
8g	1652	0.95 (3H, s, Me), 1.69 (3H, s, Me), 2.32 (3H, s, $C_6H_4C\underline{H}_3$), 4.86 (1H, s, $C\underline{H}C_6H_4Me$), 6.94-7.50 (8H, m, ArH), 7.67-7.97 (1H, m, ArH)	$C_{18}H_{19}NBrS$	76.82 76.78	6.81 6.69	4.98 4.84	11.39 11.24
8h	1656	0.98 (3H, s, Me), 1.59 (3H, s, Me), 2.35 (3H, s, $C_6H_4C\underline{H}_3$), 4.55 (1H, s, $C\underline{H}C_6H_4Me$), 6.95-7.51 (9H, m, ArH)	$C_{18}H_{19}NS$	76.82 76.87	6.81 6.74	4.98 4.84	11.39 11.38
8i	1656	0.97 (3H, s, Me), 1.58 (3H, s, Me), 2.32 (3H, s, $C_6H_4C\underline{H}_3$), 4.55 (1H, s, $C\underline{H}C_6H_4Me$), 6.93-7.53 (9H, m, ArH)	$C_{18}H_{19}NS$	76.82 76.75	6.81 6.69	4.98 4.87	11.39 11.33

[a] Compounds 8 are oily liquids.

Scheme 4



EXPERIMENTAL

All solvents were dried by standard methods. 5-Aryl-4,4-dimethyl-2-phenylisoxazolidin-3-ones (12a - 12i), *cis*-2,5-diphenyl-4-methylisoxazolidin-3-one (13), and their corresponding thiones (4a - 4i), and *cis*-2,5-

diphenyl-4-methylisoxazolidine-3-thione (10) were prepared according to the literature methods.[11] Yields, analytical, and spectroscopic data of 12a - 12i and 13 are summarized in Table 6 and those of 4a - 4i and 10 are summarized in Table 7.

Table 6. Yields, Analytical, Ir, and ^{1}H Nmr Data of 5-Aryl-4,4-dimethylisoxazolidin-3-ones (12a - 12i)[a] and 2,5-Diphenyl-4-methylisoxazolidin-3-one (13)[a]

Compound	Yield (%)	Ir (neat) (ν, cm^{-1})	^{1}H Nmr (CDCl$_3$) (δ, ppm)	Molecular Formula	Calcd/Found % C	H	N
12a	49	1702	0.90 (3H, s, Me), 1.35 (3H, s, Me), 5.20 (1H, s, $C\underline{H}C_6H_5$), 6.76-7.50 (8H, m, ArH), 7.63-7.95 (2H, m, ArH)	$C_{17}H_{17}NO_2$	76.38 76.29	6.41 6.37	5.24 5.17
12b	49	1700	1.00 (3H, s, Me), 1.51 (3H, s, Me), 5.85 (1H, s, $C\underline{H}C_6H_4Cl$), 7.05-7.56 (7H, m, ArH), 7.63-7.92 (2H, m, ArH)	$C_{17}H_{16}NO_2Cl$	67.65 67.51	5.34 5.33	4.64 4.71
12c	44	1696	0.84 (3H, s, Me), 1.32 (3H, s, Me), 5.17 (1H, s, $C\underline{H}C_6H_4Cl$), 6.93-7.49 (7H, m, ArH), 7.63-7.93 (2H, m, ArH)	$C_{17}H_{16}NO_2Cl$	67.65 67.65	5.34 5.19	4.64 4.56
12d	49	1705	0.86 (3H, s, Me), 1.30 (3H, s, Me), 5.20 (1H, s, $C\underline{H}C_6H_4Cl$), 6.97-7.53 (7H, m, ArH), 7.66-7.94 (2H, m, ArH)	$C_{17}H_{16}NO_2Cl$	67.65 67.55	5.34 5.22	4.64 4.59
12e	22	1694	0.98 (3H, s, Me), 1.52 (3H, s, Me), 5.83 (1H, s, $C\underline{H}C_6H_4Br$), 7.04-7.66 (7H, m, ArH), 7.66-7.96 (2H, m, ArH)	$C_{17}H_{16}NO_2Br$	58.96 58.84	4.66 4.63	4.04 4.01
12f	38	1696	0.85 (3H, s, Me), 1.22 (3H, s, Me), 5.16 (1H, s, $C\underline{H}C_6H_4Br$), 7.00-7.59 (7H, m, ArH), 7.69-7.88 (2H, m, ArH)	$C_{17}H_{16}NO_2Br$	58.96 58.87	4.66 4.51	4.04 4.03
12g	47	1691	0.96 (3H, s, Me), 1.35 (3H, s, Me), 2.31 (3H, s, $C_6H_4C\underline{H}_3$), 5.57 (1H, s, $C\underline{H}C_6H_4$-Me), 6.86-7.59 (7H, m, ArH), 7.64-7.98 (2H, m, ArH)	$C_{18}H_{19}NO_2$	76.82 76.81	6.81 6.80	4.98 4.84
12h	33	1696	0.89 (3H, s, Me), 1.33 (3H, s, Me), 2.37 (3H, s, $C_6H_4C\underline{H}_3$), 5.21 (1H, s, $C\underline{H}C_6H_4$-Me), 6.95-7.51 (7H, m, ArH), 7.66-8.02 (2H, m, ArH)	$C_{18}H_{19}NO_2$	76.82 76.79	6.81 6.74	4.98 4.82
12i	40	1694	0.87 (3H, s, Me), 1.28 (3H, s, Me), 2.31 (3H, s, $C_6H_4C\underline{H}_3$), 5.41 (1H, s, $C\underline{H}C_6H_4$-Me), 6.94-7.47 (7H, m, ArH), 7.64-7.97 (2H, m, ArH)	$C_{18}H_{19}NO_2$	76.82 76.72	6.81 6.74	4.98 4.92
13	42	1707	0.97 (3H, d, J = 8 Hz, Me), 3.30 (1H, s, -CHCO-), 5.77 (1H, s, J = 8 Hz, $C\underline{H}\,C_6H_5$), 7.00-7.63 (8H, m, ArH), 7.73-8.07 (2H, m, ArH)	$C_{16}H_{15}NO_2$	75.85 75.83	5.97 5.94	5.53 5.46

[a] Compounds 12 and 13 are oily liquids.

Table 7. Yields, Analytical, and ^{1}H Nmr data of 5-Aryl-4,4-dimethyl-*N*-phenylisoxazolidine-3-thiones (4a - 4i) and *cis*-2,5-Diphenyl-4-methylisoxazolidine-3-thione (10)

Compound	Yield (%)	mp (°C)	^{1}H Nmr ($CDCl_3$/TMS) δ, J (Hz)	Molecular Formula	Calcd/Found % C	H	N	S
4a	92	62 - 63 (EtOH)	0.93 (3H, s, Me), 1.43 (3H, s, Me), 5.23 (1H, s, $C\underline{H}C_6H_5$), 7.15-7.60 (8H, m, ArH), 8.07-8.37 (2H, m, ArH)	$C_{17}H_{17}NOS$	72.05 72.01	6.05 6.98	4.94 4.79	11.29 11.19
4b	94	73 - 75 (EtOH)	1.09 (3H, s, Me), 1.60 (3H, s, Me), 5.94 (1H, s, $C\underline{H}C_6H_5Cl$), 7.22-7.60 (7H, m, ArH), 8.13-8.26 (2H, m, ArH)	$C_{17}H_{16}NOClS$	64.24 64.19	5.07 5.04	4.41 4.39	10.09 10.02
4c	82	liquid	0.98 (3H, s, Me), 1.53 (3H, s, Me), 5.23 (1H, s, $C\underline{H}C_6H_5Cl$), 7.61-7.80 (7H, m, ArH), 8.20-8.41 (2H, m, ArH)	$C_{17}H_{16}NOClS$	64.24 64.13	5.07 5.03	4.41 4.29	10.09 10.05
4d	83	99 - 101 (EtOH)	0.91 (3H, s, Me), 1.41 (3H, s, Me), 5.20 (1H, s, $C\underline{H}C_6H_5Cl$), 7.09-7.60 (7H, m, ArH), 8.10-8.33 (2H, m, ArH)	$C_{17}H_{16}NOClS$	64.24 64.21	5.07 5.01	4.41 4.35	10.09 9.98
4e	74	116 - 119 (EtOH)	1.07 (3H, s, Me), 1.62 (3H, s, Me), 5.93 (1H, s, $C\underline{H}C_6H_5Br$), 7.02-7.75 (7H, m, ArH), 8.07-8.37 (2H, m, ArH)	$C_{17}H_{16}NOBrS$	56.36 56.32	4.45 4.39	3.87 3.78	8.85 8.75
4f	82	82 - 84 (EtOH)	0.90 (3H, s, Me), 1.45 (3H, s, Me), 5.22 (1H, s, $C\underline{H}C_6H_5Br$), 7.10-7.72 (7H, m, ArH), 7.97-8.32 (2H, m, ArH)	$C_{17}H_{16}NOBrS$	56.36 56.29	4.45 4.38	3.87 3.75	8.85 8.84
4g	78	99 - 101 (EtOH)	1.05 (3H, s, Me), 1.48 (3H, s, Me), 2.36 (3H, s, $C_6H_4C\underline{H}_3$), 5.64 (1H, s, $C\underline{H}C_6H_4$-Me), 7.12-7.63 (7H, m, ArH), 8.04-8.36 (2H, m, ArH)	$C_{18}H_{19}NOS$	72.69 72.58	6.44 6.39	4.71 4.69	10.78 10.61
4h	84	92 - 94 (EtOH)	0.93 (3H, s, Me), 1.41 (3H, s, Me), 2.32 (3H, s, $C_6H_4C\underline{H}_3$), 5.20 (1H, s, $C\underline{H}C_6H_4$-Me), 6.95-7.57 (7H, m, ArH), 8.04-8.37 (2H, m, ArH)	$C_{18}H_{19}NOS$	72.69 72.72	6.44 6.38	4.71 4.66	10.78 10.79
4i	97	76 - 77 (EtOH)	0.96 (3H, s, Me), 1.41 (3H, s, Me), 2.35 (3H, s, $C_6H_4C\underline{H}_3$), 5.23 (1H, s, $C\underline{H}C_6H_4$-Me), 7.13-7.61 (7H, m, ArH), 8.02-8.34 (2H, m, ArH)	$C_{18}H_{19}NOS$	72.69 72.67	6.44 6.41	4.71 4.72	10.78 10.75
10	66	liquid	1.03 (3H, d, *J* = 8 Hz, Me), 3.67 (1H, d, *J* = 8 Hz, -$C\underline{H}CS$-), 5.75 (1H, d, *J* = 8 Hz, $C\underline{H}C_6H_5$), 7.00-7.58 (8H, m, ArH), 8.00-8.38 (2H, m, ArH)	$C_{16}H_{15}NOS$	71.34 71.18	5.61 5.55	5.20 5.18	11.90 11.73

Column chromatography was performed on Kiesel gel 60 (70 - 230 mesh) from E. Merck. Melting points were determined on a Fisher-Johns melting point apparatus and are uncorrected. ^{1}H Nmr spectra were measured on a Bruker AC 80 spectrophotometer. Ir spectra were measured on a Shimadzu 470 spectrophotometer. Mass spectra were taken using a VG 12-250 mass spectrometer. Microanalyses were performed by Korea Basic Science Research Center.

Reactions of 4a - 4d with Aromatics in the Presence of $AlCl_3$ (6 equiv); General Procedure: To a solution of 4a - 4d in aromatic solvent (30 ml) was added anhydrous $AlCl_3$. The mixture was stirred at room temperature until 4a - 4d had disappeared on tlc and then quenched with water (100 ml), extracted with ether (3 × 20 ml), dried ($MgSO_4$), and evaporated to dryness. The residue was chromatographed on a silica gel column (5 × 3 cm). A mixture of compound 2-[*N*-(*p*-biphenylylimino)]-3,3-dimethyl-4-phenylthiethane (5a) and *N*-(*p*-biphenylyl)-2,2-dimethyl-3,3-diphenylpropanothioamide (7a) were obtained by elution with *n*-hexane (100 ml), followed by benzene (160 ml). The mixture was recrystallized from a mixture of carbon tetrachloride and *n*-hexane to give 5a. Evaporation of the filtrate gives 7a. 3,3-Dimethyl-4-phenyl-2-[*N*-(4-tolyl)phenylimino]thiethane (5b) and 2-[*N*-(*p*-biphenylylimino)]-4-(4-chlorophenyl)-3,3-dimethylthiethane (5e) were obtained by elution with a mixture of n-hexane and ethyl acetate (50:1, 200 ml). Continued elution with the same solvent mixture (20:1, 100 ml) gave 7b and 7e, respectively. Compounds (5c) and (5d) were obtained by elution with a mixture of n-hexane and ethyl acetate (30:1, 150 ml). Continued elution with the same solvent mixture (10:1, 200 ml) gave 7c and 7d, respectively. In each case consult Table 1 for quantities of reactants, reaction times, and yields and Table 2 and Table 3 for analytical and spectroscopic data of 5 and 7, respectively.

Reaction of 4,4-Dimethyl-2,5-diphenylisoxazolidine-3-thione (4a) with Benzene in the Presence of $AlCl_3$ (2 equiv): According to the general procedure described for the reactions of isoxazolidine-3-thione (4a - 4d) with aromatics, a mixture of 4a (315 mg, 1.11 mmol) and anhydrous $AlCl_3$ (356 mg, 2.67 mmol) in benzene (15 ml) was stirred at room temperature for 7 h. Elution with carbon tetrachloride (150 ml) gave unreacted 4a (167 mg, 53%). Elution with benzene (40 ml) gives 7a (75 mg, 16%). Continued elution with benzene (40 ml) gives 5a (31 mg, 8%). Continued elution with ether (80 ml) gave *N*-(*p*-biphenylyl)-2,2-dimethyl-3-hydroxy-3-phenylpropanothioamide (6, X = H, Ar = C_6H_5) (88 mg, 22%): mp 120 - 121 °C (from *n*-hexane): Ir (KBr) (υ, cm^{-1}) 3440 (OH), 3344 (NH); ^{1}H nmr ($CDCl_3$, δ, ppm) 1.40 (3H, s, Me), 1.50 (3H, s, Me), 3.26 (1H, d, J = 3 Hz, OH), 5.00 (1H, d, J = 3 Hz, -C<u>H</u>OH-), 7.25-7.64 (14H, m, ArH), 9.76 (1H, s, NH). Anal. Calcd for $C_{23}H_{23}NOS$: C, 76.41; H, 6.41; N 3.87; S, 8.87. Found: C, 76.54; H, 6.37; N, 3.72; S, 8.91

Reaction of Compounds (4a - 4i) with Trimethylsilyl Iodide (TMSI) in the Presence of Zinc iodide (ZnI_2); General Procedure: To a solution of compound (4a - 4i) in dried chloroform (15 ml) at room temperature were added ZnI_2 and TMSI under nitrogen atmosphere. The mixture was stirred for a given time at 50 °C by the time compounds (4a - 4i) had disappeared on tlc and then quenched with saturated sodium thiosulfate solution (10 ml). The chloroform layer was separated, dried ($MgSO_4$), and evaporated to dryness. The residue was chromatographed on a silica gel column (12 × 2 cm), eluting with benzene (150 ml) to give compounds (8a - 8i.). In each case consult Table 4 for quantities of reactants, reaction times, and yields. For the reactions (4c), and (4e - 4f), continued elution with benzene (150 ml) after eluting (8c), and (8e - 8f), gave (9c, X = 3-Cl), (9e, X = 2-Br), and (9f, X = 4-Br).

3-(3-Chlorophenyl)-2,2-dimethyl-3-hydroxy-*N*-phenylpropanothioamide (9c): 35 mg (36%); liquid: Ir (film) (υ, cm^{-1}) 3368, 3264; ^{1}H nmr ($CDCl_3$, δ, ppm) 1.30 (3H, s, Me), 1.38 (3H, s, Me), 3.89 (1H, d, *J* = 4.0 Hz, OH), 4.83 (1H, d, *J* = 4.0 Hz, $C\underline{H}C_6H_4Cl$), 7.09 - 7.58 (9H, m, ArH), 9.46 (1H, s, NH). Anal. Calcd for $C_{17}H_{18}NOClS$: C, 63.84; H, 5.67; N, 4.38; S, 10.02. Found: C, 63.75; H, 5.62; N, 4.21; S, 10.06.

3-(2-Bromophenyl)-2,2-dimethyl-3-hydroxy-*N*-phenylpropanothioamide (9e): 72 mg (29%); liquid: Ir (film) (υ, cm^{-1}) 3360, 3264; ^{1}H nmr ($CDCl_3$, δ, ppm) 1.38 (3H, s, Me), 1.53 (3H, s, Me), 4.10 (1H, d, *J* = 4.0 Hz, OH), 5.44 (1H, d, *J* = 4.0 Hz, $C\underline{H}C_6H_4Br$), 6.92 - 7.73 (9H, m, ArH), 9.96 (1H, s, NH). Anal. Calcd for $C_{17}H_{18}NOBrS$: C, 56.05; H, 4.98; N, 3.84; S, 8.80. Found: C, 56.12; H, 4.89; N, 3.75; S, 8.79.

3-(4-Bromophenyl)-2,2-dimethyl-3-hydroxy-*N*-phenylpropanothioamide (9f): 43 mg (17%); liquid: Ir (film) (υ, cm^{-1}) 3368, 3280; ^{1}H nmr ($CDCl_3$, δ, ppm) 1.33 (3H, s, Me), 1.43 (3H, s, Me), 3.53 (1H, d, *J* = 4.0 Hz, OH), 4.93 (1H, d, *J* = 4.0 Hz, $C\underline{H}C_6H_4Br$), 7.08 - 7.64 (9H, m, ArH), 9.48 (1H, s, NH). Anal. Calcd for $C_{17}H_{18}NOBrS$: C, 56.05; H, 4.98; N, 3.84; S, 8.80. Found: C, 56.20; H, 4.83; N, 3.71; S, 8.74.

Reaction of *cis*-2,5-Diphenyl-4-methylisoxazolidine-3-thione (10) with TMSI in the Presence of ZnI_2: According to the general procedure described for the reactions of 4a - 4i with TMSI in the presence of zinc iodide, a solution of compound 10 (299 mg, 1.11 mmol), ZnI_2 (710 mg, 2.22 mmol), and TMSI (1.34 g, 6.68 mmol) in chloroform (15 ml) was stirred for 6 days. Chromatography of the reaction mixture gave *trans*-3-methyl-4-phenyl-2-(*N*-phenylimino)thiethane (11) (164 mg, 58%); liquid: Ir (film) (υ, cm^{-1}) 1667 (C=N); ^{1}H nmr ($CDCl_3$, δ, ppm) 1.49 (3H, d, *J* = 7.2 Hz, Me), 4.13 (1H, m, -C$\underline{H}$CS-), 4.39 (1H, d, *J* = 4.6 Hz, $C\underline{H}C_6H_5$), 6.93 - 7.70 (10H, m, ArH). Anal. Calcd for $C_{16}H_{15}NS$: C, 75.85; H, 5.97; N 5.53; S, 12.65. Found: C, 75.73; H, 5.89; N, 5.48; S, 12.67.

Reaction of 9c with TMSI in the Presence of Zinc Iodide: According to the procedure described for the reactions of 4a - 4i with TMSI in the presence of ZnI_2, a solution of 9c (126 mg, 0.393 mmol), ZnI_2 (260 mg, 0.815 mmol), and TMSI (576 mg, 2.88 mmol) was stirred for 3 days. Chromatography of the reaction mixture using benzene (100 ml) as an eluent gave 4-(3-chlorophenyl)-3,3-dimethyl-2-(*N*-phenylimino)thiethane (8c) (86 mg, 73%) and 9c (32 mg, 25 %).

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