Study on the Reaction of Isoxazolidine-3-thiones with Anhydrous Aluminum Chloride: Synthesis and Mechanism of the Formation of *N*-(*p*-Biphenylyl)-3-aryl-3-phenylpropanothioamides

Youngwan Seo and Kyongtae Kim*

Department of Chemistry, Seoul National University, Seoul 151-742, Korea
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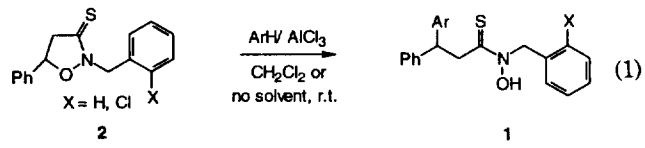
The reaction of 5-aryl-2-phenylisoxazolidine-3-thiones with more than 3 equivalents of anhydrous aluminum chloride in benzene at reflux gave *N*-(*p*-biphenylyl)-3-aryl-3-phenylpropanothioamides in good yields. It is conceived that the propanothioamides are formed via the formation of the corresponding *N*-phenyl-3-aryl-3-phenylpropanothiohydroxamic acids.

Introduction

Previously we reported a new method for the synthesis of *N*-benzyl-3-aryl-3-phenylpropanothiohydroxamic acids (**1**),[1] which have attracted much attention because they have not only biological activities[2] such as insecticides and antibiotics but also act as excellent metal chelators. The compouds **1** were prepared by the reaction of 2-benzyl-5-phenylisoxazolidine-3-thiones (**2**) with aromatics such as toluene, biphenyl, *p*-xylene, and chlorobenzene in the presence of anhydrous aluminum chloride in methylene chloride at room temperature (eq. 1).



As part of our studies to widen the scope of the useful reaction for the synthesis of thiohydroxamic acids starting from 5-arylisoxazolidine-3-thiones, 2,5-diphenylisoxazolidine-3-thione (**3a**) was treated with anhydrous aluminum chloride in benzene. Unexpectedly the reaction proceeded in different ways. Our results are described herein.

Results and Discussion

The reaction of **3a** with anhydrous aluminum chloride in benzene gave different products depending on the reaction conditions as shown in equations 2-4.

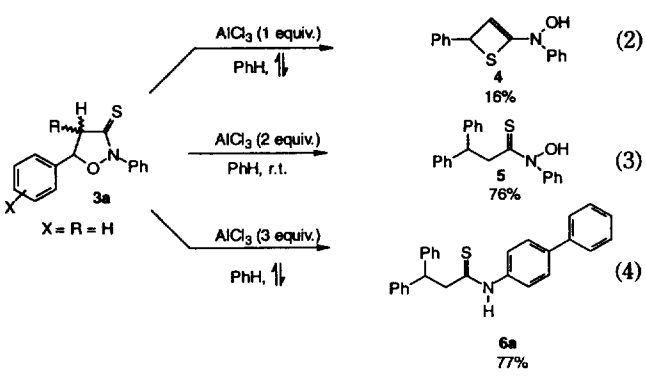
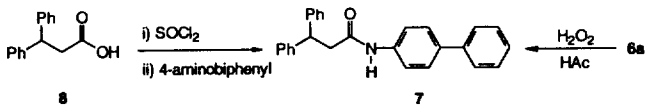


Table1. Synthesis of *N*-(*p*-biphenylyl)-3-aryl-3-phenylpropanothioamides (**6**)

Entry	Compound 3			$AlCl_3$	PhH	Time	Yield†
	X	R	mmol	mmol	mL	min	%
a	H	H	0.45	1.58	20	30	76
b	2-Cl	H	1.02	3.50	10	30	89
c	3-Cl	H	1.02	3.47	10	30	79
d	4-Cl	H	1.42	4.91	30	20	72
e	2-Cl	Me	0.57	1.96	10	30	77‡
f	4-Me	H	0.73	2.56	10	30	**
g	4-MeO	H	0.91	3.12	10	20	§

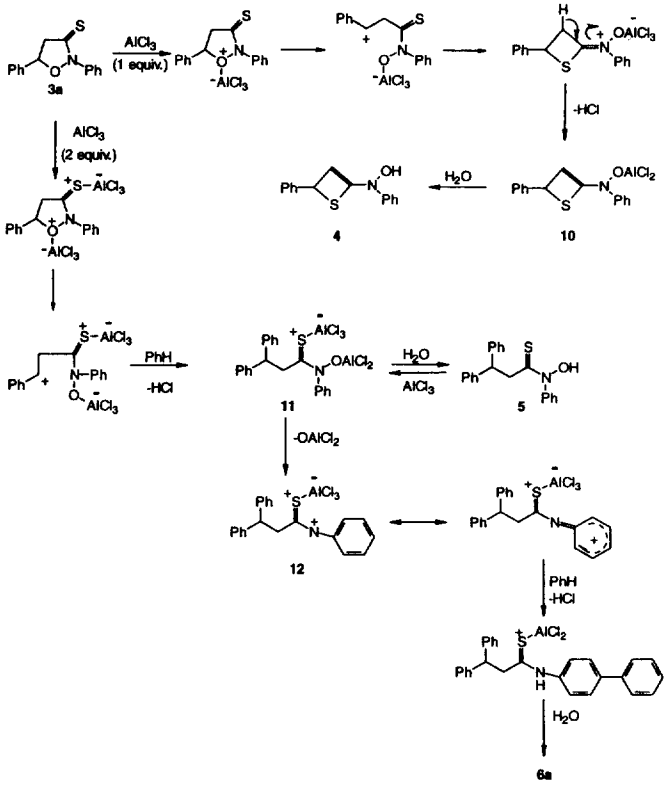
†Isolated yield. ‡*cis*-Compound **3e** was used. Compound **6e** was a mixture of erythro-(52%) and threo-isomers (25%). **Compound **6a** was isolated in 55% yield. §*N*-phenyl-3-(*p*-anisyl)-3-phenylpropanothiohydroxamic acid (**9**) was isolated in 22% yield.

The structures of 4-phenyl-2-(*N*-hydroxy-*N*-phenyl)aminothiene (**4**), 3,3,*N*-triphenylpropanothiohydroxamic acid (**5**), and *N*-(*p*-biphenylyl)-3,3-diphenylpropanothioamide (**6a**) were characterized on the basis of the spectroscopic and mass spectral data. In particular, the structure of **6a** was further confirmed by comparison of that of *N*-(*p*-biphenylyl)-3,3-diphenylpropanamide (**7**) obtained by oxidation of **6a** with 28% H_2O_2 in acetic acid with that of the authentic compound synthesized independently starting from 3,3-diphenylpropanoic acid (**8**).



Analogous *N*-(*p*-biphenylyl)-3-aryl-3-phenylpropanothioamides (**6b-6g**) were prepared using 3.5 equivalents of anhydrous aluminum chloride under the same conditions as with the preparation of compound **6a**. The results are summarized in Table 1.

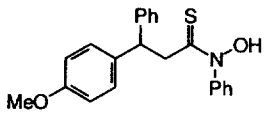
It is noteworthy that the reaction of 2-phenyl-5-(*p*-tolyl)isoxazolidine-3-thione (**3f**) do not give the expected compound, *N*-(*p*-biphenylyl)-3-phenyl-3-(*p*-tolyl)propanothioamide (**6f**, X =4-Me, R=H) but compound **6a** in 56% yield. Demethylation of tolyl group is interesting in view of the general trend



Scheme 1.

in which methyl groups in methylated benzenes normally migrate rather than disappear in the presence of anhydrous aluminum chloride.[3] At this moment, it is uncertain whether demethylation occurs prior to the formation of **6a** or after the formation of **6a**.

In contrast, the reaction of 5-(*p*-anisyl)-2-phenylisoxazolidine-3-thione (**3g**) gave *N*-phenyl-3-(*p*-anisyl)-3-phenylpropanothiohydroxamic acid (**9**) in 22% yield as well as a mixture



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of unknown compounds. The formation of thiohydroxamic acid **9** instead of **6g** (X=4-MeO, R=H) might be due to decrease of the concentration of free aluminum chloride in less than 3 equivalents by complexation with the oxygen atom of the methoxy group.[4] This is in accord with the trend in which compound **5** is formed from compound **3a** in the presence of approximately 2 equivalents of aluminum chloride (eq. 2).

In order to ascertain the intermediacy of compound **5** for the formation of compound **6**, compound **5** was treated with anhydrous aluminum chloride in benzene at reflux. From the reaction was obtained compound **6** in 76% yield. This result indicates clearly the involvement of *N*-phenylthiohydroxamic acid **5** as an intermediate for the formation of *N*-biphenylylthioamide **6**. The mechanism of the formations of compounds **4**, **5**, and **6a** are proposed as shown in Scheme 1.

In the presence of 1 equivalent of anhydrous aluminum chloride a bond between C-5 and oxygen atom having a positive charge developed by an interaction with aluminum chloride is cleaved readily to generate a benzylic cation which then undergoes a series of the reaction, *i.e.* intramolecular cyclization, elimination of HCl, and hydrolysis, to give compound **4**. Since no product incorporating a solvent molecule was detected, the intramolecular cyclization is thought to be much faster than the intermolecular nucleophilic attack of benzene molecule at the benzylic cation.

On the other hand, both of oxygen and sulfur atoms having nonbonding electrons of **3a** is conceived to act as Lewis bases in the presence of a slightly excess of 2 equivalents but less than 3 equivalents of anhydrous aluminum chloride at room temperature. Consequently an intramolecular nucleophilic attack by sulfur atom of its thione **3a** at the benzylic cation is expected to be blocked. As a result, benzene molecules being a solvent readily attack the benzylic cation to give eventually compound **5**. In the presence of more than 3 equivalents of anhydrous aluminum chloride at reflux, one might think of a nitrenium ion **12** generated by loss of $^{-}OAlCl_2$ ion either by itself or by the assistance of extra molecule of aluminum chloride. This is similar to the generation of a nitrenium ion as an intermediate by treatment of *N*-phenyl-3-phenylpropanohydroxamic acid with trifluoromethanesulfonic acid.[5] The nitrenium ion **12** can be stabilized by delocalization of the positive charge into the phenyl ring and the positive charge in the phenyl ring is trapped by benzene molecule to give compound **6a**.[6] No ortho and meta biphenylyl derivatives were detected. Further study on the effects of the substituents at C-4 in the presence of different Lewis acids is in progress.

Experimental

All solvents were dried by standard methods. Anhydrous aluminum chloride was obtained from Aldrich and phosphorus pentasulfide was from E. Merck. Column chromatography was performed on silica gel (Merck 70-230 mesh ASTM). Melting points were determined on a Fischer-Johns melting point apparatus and are uncorrected. ^{1}H NMR spectra were measured on either a Brucker AC 80 Spectrometer or a Varian EM 360 A Spectrometer. IR spectra were determined on a Perkin-Elemer Model 782 Spectrometer. Mass spectra were measured on VG 12-250 Mass Spectrometer. Microanalyses were performed by the Korea Basic Science Center.

5-Aryl-2-phenylisoxazolidine-3-thiones (**3**) were prepared according to the literature method.[1]

2,5-Diphenylisoxazolidine-3-thione (3a). yield: 94%; mp 58-59 ℃ (*n*-hexane); ^{1}H NMR ($CDCl_3$, 60 MHz) δ 3.67 (dd, 1H, *J*=17, 10 Hz, CH_2CS), 4.02 (dd, 1H, *J*=17, 10 Hz, CH_2CS), 7.33-7.73 (m, 8H, Ar), 8.10-8.38 (m, 2H, Ar); IR (KBr) 1590, 1488, 1460, 1400, 1319, 1301, 1211, 1177, 1143, 1071, 1044, 1027, 1010, 978, 900, 835, 753, 698, 687, and 540 cm^{-1}. Anal. Calcd for $C_{15}H_{13}NOS$: C, 70.56; H, 5.13; N, 5.49; S, 12.56. Found: C, 70.48; H, 5.26; N, 5.51; S, 12.74.

5-(2-Chlorophenyl)-2-phenylisoxazolidine-3-thione (3b). yield: 80%; 1H NMR ($CDCl_3$, 60 MHz) δ 3.55 (dd, 1H, *J*=17, 9 Hz, CH_2CS), 4.16 (dd, 1H, *J*=17, 9 Hz, CH_2CS), 6.11 (t, 1H, *J*=9 Hz, -CHO), 7.22-7.83 (m, 7H, Ar), 8.15-8.53

(m, 2H, Ar); IR (KBr) 1590, 1486, 1460, 1438, 1395, 1301, 1144, 1052, 980, 904, 752, and 686 cm^{-1}. Anal. Calcd for $C_{15}H_{12}NClOS$: C, 62.17; H, 4.17; N, 4.83; S, 11.06. Found: C, 62.28; H, 4.31; N, 4.65; S, 11.21.

5-(3-Chlorophenyl)-2-phenylisoxazolidine-3-thione (3c). yield: 93%; ^1H NMR ($CDCl_3$, 60 MHz) δ 3.56 (dd, 1H, J=17, 9 Hz, CH_2CS), 3.97 (dd, 1H, J=17, 9 Hz, CH_2CS), 5.68 (t, 1H, J=9 Hz, -CHO), 7.24-7.74 (m, 7H, Ar), 8.05-8.43 (m, 2H, Ar); IR (KBr) 1590, 1571, 1487, 1461, 1400, 1303, 1209, 1144, 1118, 1099, 1080, 1045, 1028, 980, 902, 885, 758, 735, and 687 cm^{-1}. Anal. Calcd for $C_{15}H_{12}NClOS$: C, 62.17; H, 4.17; N, 4.83; S, 11.06. Found: C, 62.33; H, 4.30; N, 4.73; S, 11.24.

5-(4-Chlorophenyl)-2-phenylisoxazolidine-3-thione (3d). yield: 89%; ^1H NMR ($CDCl_3$, 60 MHz) δ 3.50 (dd, 1H, J=18, 9 Hz, CH_2CS), 4.32 (dd, 1H, J=18, 9 Hz, CH_2CS), 5.60 (t, 1H, J=9 Hz, -CHO), 7.13-7.60 (m, 7H, Ar), 7.90-8.26 (m, 2H, Ar); IR (KBr) 1590, 1490, 1461, 1400, 1319, 1302, 1211, 1176, 1145, 1092, 1045, 1028, 1014, 979, 900, 828, 755, and 686 cm^{-1}. Anal. Calcd for $C_{15}H_{12}NClOS$: C, 62.17; H, 4.17; N, 4.83; S, 11.06. Found: C, 62.28; H, 4.32; N, 4.86; S, 11.19.

2-Phenyl-5-(*p*-tolyl)isoxazolidine-3-thione (3f). yield: 95%; ^1H NMR ($CDCl_3$, 60 MHz) δ 2.35 (s, 3H, Me), 3.60 (dd, 1H, J=17, 9 Hz, CH_2CS), 3.93 (dd, 1H, J=17, 9 Hz, CH_2CS), 5.68 (t, 1H, J=9 Hz, -CHO), 7.12-7.68 (m, 7H, Ar), 8.01-8.34 (m, 2H, Ar); IR (KBr) 1590, 1490, 1461, 1398, 1303, 1144, 980, 900, 855, 815, and 687 cm^{-1}. Anal. Calcd for $C_{16}H_{15}NOS$: C, 71.34; H, 5.61; N, 5.20; S, 11.90. Found: C, 71.54; H, 5.79; N, 5.32; S, 12.90.

5-(*p*-Anisyl)-2-phenylisoxazolidine-3-thione (3g). yield: 92%; ^1H NMR ($CDCl_3$, 60 MHz) δ 3.63 (dd, 1H, J=18, 9 Hz, CH_2CS), 3.85 (s, 3H, OMe), 3.94 (dd, 1H, J=18, 9 Hz, CH_2CS), 5.70 (t, 1H, J=9 Hz, -CHO), 7.03 (d, 2H, J=9 Hz, Ar), 7.33-7.75 (m, 5H, Ar), 8.10-8.40 (m, 2H, Ar); IR (KBr) 1613, 1588, 1518, 1490, 1431, 1399, 1301, 1253, 1179, 1144, 1030, 978, 883, 830, 755, and 695 cm^{-1}. Anal. Calcd for $C_{16}H_{15}NO_2S$: C, 67.34; H, 5.30; N, 4.91; S, 11.23. Found: C, 67.28; H, 5.33; N, 5.02; S, 11.36.

***cis*-5-(2-Chlorophenyl)-4-methyl-2-phenylisoxazolidine-3-thione (3e).** (i) A solution of 3-bromo-3-(2-chlorophenyl)-2-methylpropanoic acid (1.57 g, 5.66 mmol) in thionyl chloride (5 mL) was heated at reflux for 1 h. After removal of the excess thionyl chloride, the residue was dissolved in dried benzene (30 mL), which was added dropwise to a mixture of phenylhydroxylamine (2.59 g, 23.7 mmol) and chlorotrimethylsilane (1.20 g, 11.0 mmol) in dried benzene (30 mL) cooled to an ice-water temperature for a 6 min. The reaction mixture was stirred for 1 h at an ice-water temperature, washed with water, and extracted with benzene. The organic layer was dried over anhydrous magnesium sulfate. To the organic layer was added triethylamine (1.45 g, 14.3 mmol), which was heated at reflux for 4 h, followed by washing with water. The benzene layer was dried over anhydrous magnesium sulfate. Evaporation of the solvent gave a residue, which was chromatographed on silica gel column (2 × 14 cm). Elution with *n*-hexane gave azoxybenzene (97 mg, 0.49 mmol). Elution with benzene gave *cis*-5-(2-chlorophenyl)-4-methyl-2-phenylisoxazolidin-3-one (**13**) (796 mg, 2.77 mmol, 49%): ^1H NMR ($CDCl_3$, 60 MHz) δ 0.97 (d, 3H, J=8 Hz, Me), 3.53 (quintet, 1H, J=7.8 Hz, -CHCO), 6.12 (d, 1H, J=7.8 Hz, -CHO), 7.08-7.79 (m, 7H, Ar), 7.79-8.10 (m, 2H, Ar); IR (KBr) 1703 (CO) cm^{-1}. Anal. Calcd for $C_{16}H_{14}NClO_2$: C, 66.79; H, 4.90; N, 4.87. Found: C, 66.84; H, 5.10; N, 4.69.

(ii) A mixture of compound **13** (1.02 g, 3.54 mmol) and phosphorus pentasulfide (3.17 g, 7.13 mmol) in benzene (30 mL) was heated at reflux for 1.5 h. The mixture was cooled to room temperature, followed by addition of water (20 mL). The benzene layer was separated, washed with water, and dried over anhydrous magnesium sulfate. Evaporation of the solvent, followed by chromatography of the residue using benzene as an eluent gave compound **3e** (904 mg, 2.98 mmol, 84%): mp 93-94 ℃ (*n*-hexane); ^1H NMR ($CDCl_3$, 60 MHz) δ 1.11 (d, 3H, J=8 Hz, Me), 4.01 (quintet, 1H, J=8 Hz, -CHCO), 6.21 (d, 1H, J=8 Hz, -CHO), 7.23-7.81 (m, 7H, Ar), 8.18-8.50 (m, 2H, Ar); IR (KBr) 1585, 1492, 1432, 1347, 1287, 1143, 1067, 1052, 1021, 990, 967, 875, 769, 757, 740, 690, and 676 cm^{-1}. Anal. Calcd for $C_{16}H_{14}NClOS$: C, 63.26; H, 4.65; N, 4.61.; S, 10.55. Found: C, 63.39; H, 4.76; N, 4.64; S, 10.64.

General procedure for the reaction of **3** with anhydrous aluminum chloride.

To a solution of compound **3** (0.45-1.96 mmol) in benzene (10-30 mL) was added an appropriate amount of anhydrous aluminum chloride. The mixture was stirred either at room or reflux temperature and then quenched with water. The mixture was extracted with methylene chloride. The organic layer was dried over anhydrous magnesium sulfate. Evaporation of the solvent gave a residue, which was chromatographed on silica gel.

(i) The molar ratio (1 : 1) of **3a** to anhydrous aluminum chloride.

A mixture of **3a** (438 mg, 1.72 mmol) and anhydrous aluminum chloride (320 mg, 2.40 mmol) in benzene (16 mL) was refluxed for 1 h. Chromatography of the reaction mixture using benzene as an eluent gave unreacted **3a** (63 mg, 0.25 mmol) and a mixture of unknown compounds (50 mg). Elution with chloroform gave compound **4** (70 mg, 0.27 mmol, 16%): ^1H NMR ($CDCl_3$, 60 MHz) δ 4.65 (d, 1H, J=3 Hz, -CH-), 7.18-7.46 (m, 10H, Ar), 8.78 (d, 1H, J=3 Hz, -CH=), 12.89 (s, 1H, OH); IR (KBr) 3045 (br), 1630, 1590, and 1545 cm^{-1}; MS (m/e) 255 (M^+). Anal. Calcd for $C_{15}H_{13}NOS$: C, 70.56; H, 5.13; N, 5.49.; S, 12.56. Found: C, 70.67; H, 5.30; N, 5.51; S, 12.67.

(ii) The molar ratio (1 : 2) of **3a** to anhydrous aluminum chloride.

A mixture of **3a** (85 mg, 0.33 mmol) and anhydrous aluminum chloride (84 mg, 0.63 mmol) in benzene (10 mL) was stirred for 35 min at room temperature. Chromatography of the reaction mixture using benzene as an eluent gave compound **5** (82 mg, 0.25 mmol, 76%): mp 77-78 ℃ (*n*-hexane); ^1H NMR ($CDCl_3$, 60 MHz) δ 3.27 (d, 2H, J=8 Hz, CH_2), 4.92 (t, 1H, J=8 Hz, -CH-), 6.74-7.43 (m, 15H, Ar), 11.23 (s, 1H, OH); IR (KBr) 3055 (br), 1590, and 1520 cm^{-1}. Anal. Calcd for $C_{21}H_{19}NOS$: C, 75.64; H, 5.74; N, 4.20; S, 9.61. Found: C, 75.59; H, 5.77; N, 4.18; S, 9.78.

(iii) The molar ratio (1 : 3) of **3a** to anhydrous aluminum chloride.

Refer to Table 1 for the amounts of compounds **3**, aluminum chloride, and yields of the products **6**.

6a: mp 182-183 ℃ (CCl_4); ^1H NMR ($CDCl_3$, 60 MHz) δ 3.55 (d, 2H, J=8 Hz, CH_2), 3.83 (t, 1H, J=8 Hz, -CH-), 7.20-

7.57 (m, 19H, Ar), 8.08 (s, 1H, NH); IR (KBr) 3310 (NH) cm^{-1}; MS (m/e) 393 (M^+). Anal. Calcd for $C_{27}H_{23}NS$: C, 82.40; H, 5.89; N, 3.56; S, 8.15. Found: C, 82.33; H, 5.75; N, 3.43; S, 8.29.

***N*-(*p*-Biphenylyl)-3-(2-chlorophenyl)-3-phenylpropanothioamide (6b).** mp 163-164 ℃ (CCl_4); ^1H NMR ($CDCl_3$, 60 MHz) δ 3.46 (d, 2H, J=8 Hz, CH_2), 5.32 (t, 1H, J=8 Hz, -CH-), 7.03-7.78 (m, 18H, Ar), 8.73 (s, 1H, NH); IR (KBr) 3200 (NH) cm^{-1}. Anal. Calcd for $C_{27}H_{22}NClS$: C, 75.77; H, 5.18; N, 3.27; S, 7.49. Found: C, 75.81; H, 5.20; N, 3.38; S, 7.61.

***N*-(*p*-Biphenylyl)-3-(3-chlorophenyl)-3-phenylpropanothioamide (6c).** mp 169-170 ℃ (CCl_4); ^1H NMR ($CDCl_3$, 60 MHz) δ 3.49 (d, 2H, J=8 Hz, CH_2), 4.78 (t, 1H, J=8 Hz, -CH-), 7.21-7.64 (m, 18H, Ar), 8.18 (s, 1H, NH); IR (KBr) 3180 (NH) cm^{-1}. Anal. Calcd for $C_{27}H_{22}NClS$: C, 75.77; H, 5.18; N, 3.27; S, 7.49. Found: C, 75.94; H, 5.02; N, 3.34; S, 7.65.

***N*-(*p*-Biphenylyl)-3-(4-chlorophenyl)-3-phenylpropanothioamide (6d).** mp 187-189 ℃ (CCl_4); ^1H NMR ($CDCl_3$, 60 MHz) δ 3.48 (d, 2H, J=8 Hz, CH_2), 4.93 (t, 1H, J=8 Hz, -CH-), 6.93-7.82 (m, 18H, Ar), 10.75 (s, 1H, NH); IR (KBr) 3300 (NH) cm^{-1}. Anal. Calcd for $C_{27}H_{22}NClS$: C, 75.77; H, 5.18; N, 3.27; S, 7.49. Found: C, 75.69; H, 4.99; N, 3.31; S, 7.64.

Reaction of **3e** with anhydrous aluminum chloride.

Chromatography of the reaction mixture (refer to Table 1 and general procedure) using benzene as an eluent gave a sticky mixture (242 mg), which was crystallized from chloroform to give erythro-*N*-(*p*-biphenylyl)-3-(2-chlorophenyl)-2-methyl-3-phenylpropanothioamide (131 mg, 0.29 mmol, 52%): mp 271-273 ℃ (CCl_4); ^1H NMR ($CDCl_3$+DMSO-d_6, 80 MHz) δ 1.24 (d, 3H, J=7 Hz, Me), 3.91-4.21 (m, 1H, -CHCS-), 5.07 (d, 1H, J=12 Hz, Ar_2CH-), 7.07-7.62 (m, 17H, Ar), 7.81-7.92 (m, 1H, Ar), 11.61 (s, 1H, NH); IR (KBr) 3185 (NH) cm^{-1}. Anal. Calcd for $C_{28}H_{24}NClS$: C, 76.08; H, 5.47; N, 3.17; S, 7.25. Found: C, 76.01; H, 5.59; N, 3.32; S, 7.09. Removal of the solvent from the filtrate, followed by treatment of the residue with *n*-hexane gave an oily liquid (63 mg, 0.14 mmol, 25%), identified to be threo-*N*-(*p*-biphenylyl)-3-(2-chlorophenyl)-2-methyl-3-phenylpropanothioamide: ^1H NMR ($CDCl_3$, 80 MHz) δ 1.42 (d, 3H, J=6 Hz, Me), 3.42-3.86 (m, 1H, -CHCS-), 5.04 (d, 1H, J=11 Hz, Ar_2CH-), 6.95-7.80 (m, 18H, Ar), 8.90 (s, 1H, NH); IR (KBr) 3230 (NH) cm^{-1}. Evaporation of the solvent from the filtrate gave 2-biphenylylimino-4-(2-chlorophenyl)-3-methylthiethane (48 mg, 0.13 mmol); MS (m/e) 363 (M^+); IR (KBr) 1670 (C=N) cm^{-1}. Anal. Calcd for $C_{28}H_{24}NClS$: C, 76.08; H, 5.47; N, 3.17; S, 7.25. Found: C, 76.22; H, 5.56; N, 3.08; S, 7.12.

Reaction of **3g** with anhydrous aluminum chloride.

A mixture of 3g (259 mg, 0.91 mmol) and anhydrous aluminum chloride (416 mg, 3.12 mmol) in benzene (10 mL) was refluxed for 20 min. Chromatography of the reaction mixture using benzene as an eluent gave a mixture (62 mg) of unknown compounds and **9** (73 mg, 0.20 mmol, 22%): ^1H NMR ($CDCl_3$, 60 MHz) δ 3.32 (d, 2H, J=8 Hz, CH_2), 3.82 (s, 3H, OMe), 5.00 (t, 1H, J=8 Hz, -CH-), 6.74-7.71 (m, 14H, Ar), 11.45 (s, 1H, OH); IR (KBr) 3054, 3020, 1607, 1510, 1405, 1249, 1177, 1032, 831, 767, 698, and 550 cm^{-1}. $C_{22}H_{21}NO_2S$: C, 72.70; H, 5.82; N, 3.85; S, 8.82. Found: C, 72.61; H, 5.75; N, 3.69; S, 8.79.

Reaction of **3f** with anhydrous aluminum chloride.

A mixture of **3f** (196 mg, 0.73 mmol) and anhydrous aluminum chloride (342 mg, 2.56 mmol) in benzene (10 mL) was refluxed for 30 min. Chromatography of the reaction mixture using benzene as an eluent gave **6a** (159 mg, 0.40 mmol, 55%).

***N*-(*p*-Biphenylyl)-3,3-diphenylpropanamide (7).** (i) To a solution of **6a** (287 mg, 0.73 mmol) in acetic acid (10 mL) was added 28% hydrogen peroxide (89 mg, 2.61 mmol). The mixture was heated for 1 h at reflux, followed by addition of water (20 mL). The mixture was extracted with benzene three times. The organic layer was dried over anhydrous magnesium sulfate. Evaporation of the solvent gave compound **7** (251 mg, 0.66 mmol, 90%): ^1H NMR ($CDCl_3$ +DMSO-d_6, 80 MHz) δ 3.12 (d, 2H, J=8 Hz, CH_2), 4.71 (t, 1H, J=8 Hz, -CH-), 7.13-7.61 (m, 19H, Ar), 8.97 (s, 1H, NH); IR (KBr) 3340 (NH) and 1663 (C=O) cm^{-1}; MS (m/e) 378 (M^+). $C_{27}H_{23}NO$: C, 85.91; H, 6.14; N, 3.71. Found: C, 85.88; H, 6.06; N, 3.79.

(ii) A solution of 3,3-diphenylpropanoic acid (**8**) (336 mg, 1.48 mmol) in thionyl chloride (2 mL) was heated for 1 h at reflux. After the removal of the excess thionyl chloride in vacuo, the residue in ether (20 mL) was added to a mixture of 4-aminobiphenyl (256 mg, 1.51 mmol) and triethylamine (168 mg, 1.66 mmol) in ether (20 mL). The mixture was stirred for 15 min at room temperature. Benzene (10 mL) and water (20 mL) were added to the reaction mixture and the organic layer was separated and dried over anhydrous magnesium sulfate. Evaporation of the solvent, followed by recrystallization of the residue from benzene gave compound **7** (531 mg, 1.41 mmol, 95%).

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