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The Thionium/*N*-Acyliminium Ion Cyclization Cascade as a Strategy for the Synthesis of Azapolycyclic Ring Systems

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Abstract—A series of amidosulfoxides were prepared by the addition of thiophenol to the appropriate alkenoic acid π-bond, and this was followed by reaction of the in situ generated acyl chloride with 3,4-dimethoxyphenethyl amine. The silicon-induced Pummerer reaction of these amidosulfoxides was carried out using 1-(dimethyl-*tert*-butylsiloxy)-1-methoxyethylene in dry acetonitrile in the presence of a catalytic amount of ZnI_2 and led to the very clean formation of 2-thiophenyl substituted lactams. Iminium ion-aromatic π-cyclization was accomplished by treatment of the initially formed thiophenyl lactams with $BF_3{\cdot}2AcOH$ which resulted in the generation of an *N*-acyliminium ion. Cyclization of the iminium ion onto the tethered aromatic ring led to various azapolycyclic ring systems. A related cyclization sequence also occurred with amidosulfoxides that possess simple olefinic tethers. The method was applied toward the synthesis of a member of the protoberberine alkaloid family.

Nitrogen containing heterocycles are widely distributed in nature and many of these compounds display important biological activity.[1] A vast number of natural and synthetic *N*-heterocyclic compounds have found applications as pharmaceutical and agricultural chemicals.[2] Accordingly, novel methods of preparing *N*-heterocycles has attracted much interest in recent years.[3–9] A variety of synthetic methodologies have been developed and many reviews, monographs, and reports have been released.[1] Despite the wide availability of different methods, there still exists a need for developing more efficient procedures which allow the ready synthesis of complex azapolycyclic ring systems. In recent years, the Pummerer reaction followed by a π-cyclization has been found to be a very effective and general method for the preparation of many diverse azapolycyclic ring systems.[10–12] By positioning a nitrogen atom in the tether between the electrophilic thionium ion and a nucleophile π-system, the Pummerer reaction has been used to generate numerous nitrogen heterocycles.[13–19] Another exceptionally viable strategy that has also been employed to prepare a variety of five and six-membered nitrogen heterocycles involves the addition of nucleophiles to *N*-acyliminium ions. In particular, the intramolecular reaction of cyclic *N*-acyliminium ions has been successfully utilized for the preparation of various azabicyclic ring systems found in natural products.[20–31]

Our interest in indolizidine/quinolizidine alkaloid synthesis led us to explore the thionium/*N*-acyliminium ion cascade as a key strategy for the assembly of these ring systems.[32] The approach we had in mind was based on our previous success using a tandem Pummerer/Mannich cyclization sequence for synthesis of the erythrinane alkaloid skeleton.[33] We envisioned that thionium ion **2**, derived from a Pummerer reaction of sulfoxide **1**, would readily react with the neighboring amido nitrogen atom to provide the 2-thiophenyl substituted lactam **3** (Scheme 1). Subsequent elimination of the thiophenyl group should ultimately lead to the azabicyclic lactam **5** via cyclization of a transient *N*-acyliminium ion (i.e. **4**). In this paper, we report an account of our efforts dealing with this unique tandem cyclization sequence.[34]

We began our investigations of the sequential Pummerer/*N*-acyliminium ion cascade by first examining the intramolecular thionium ion cyclization reaction of amidosulfoxide **8**. Treatment of isatoic anhydride (**6**) with the anion of dimethyl sulfoxide furnished *o*-amino-ω-methylsulfinylacetophenone (**7**).[35] Heating a sample of **7** with acetic anhydride at 80°C in benzene for 12 h afforded the desired amidosulfoxide **8**.[36] The Pummerer cyclization of **8**→**9** requires (1) an electrophile to activate the sulfoxide and to transform the oxygen into a good leaving group, (2) a general base to remove the proton, and (3) the amido nitrogen atom to preferentially attack the thionium ion intermediate to give the cyclized 1,2-dihydroindolone. The Pummerer reaction has been initiated with a variety of electrophilic reagents (Pummerer promoters).[37] Acetic anhydride is by far the most commonly used promoter and is often utilized as the solvent at reflux temperature or in combination with other solvents or cocatalysts. We found

Keywords: thionium/*N*-acyliminium; azapolycyclic ring system; Pummerer reaction.

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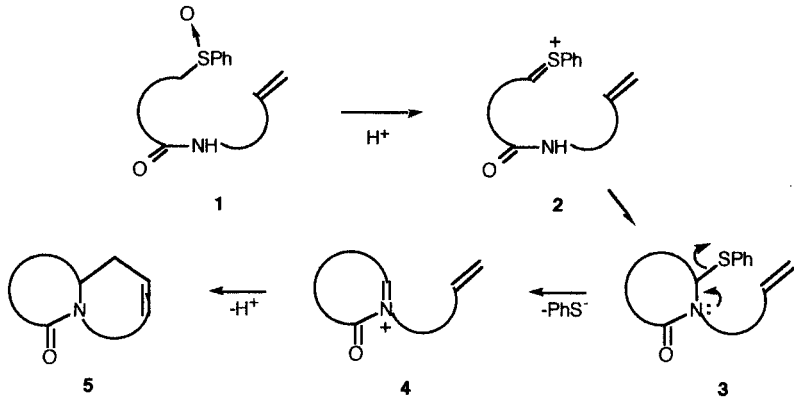
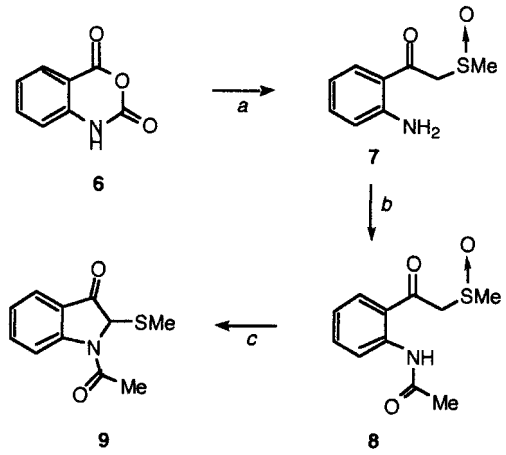


Scheme 1.

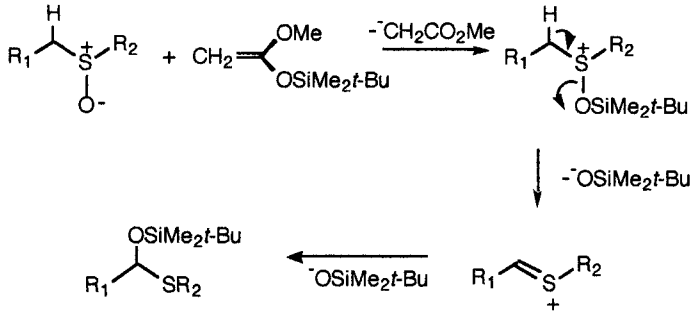


Scheme 2. Reagents: (a) NaH, DMSO; (b) Ac_2O, 80°C; (c) TBDMSOC-(OMe)=CH_2, ZnI_2.

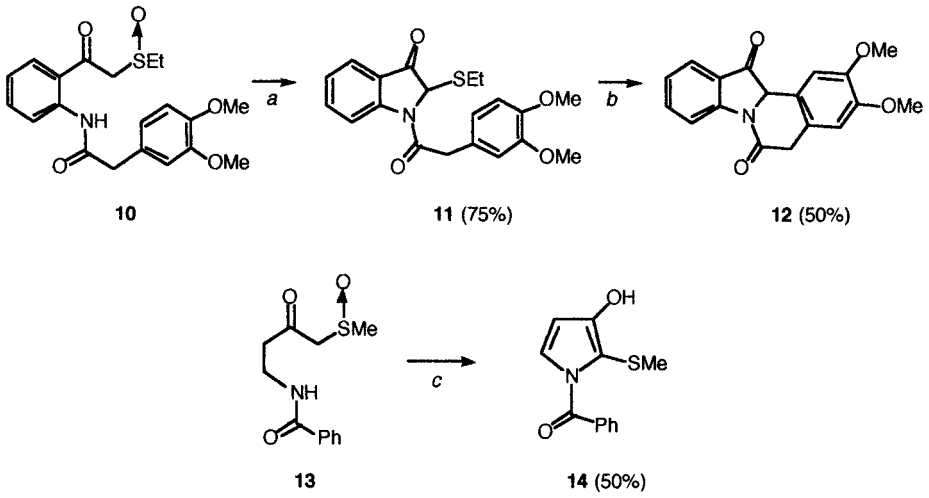
that at the elevated temperatures necessary to induce cyclization of **8** to **9**, competitive formation of an α-acetoxy sulfide occurred. This sulfide was quite labile and resulted in a mixture of products on attempted purification. With the above system, the initially generated thionium ion is not only captured internally by the adjacent amido nitrogen (ca 40%), but it also reacts with an external nucleophile (i.e. AcO^-) to furnish the acetoxy sulfide. The reaction of **8** with the more electrophilic trifluoroacetic anhydride was also studied, as it allowed the reaction to proceed under milder conditions. However, this reaction resulted mainly in the formation of an α-trifluoroacetoxy sulfide which proved to be extremely labile toward moisture.

After some experimentation with other known Pummerer promoters, we found that the highest yield of dihydroindolone **9** (94%) was obtained from the reaction of **8** with 1-(dimethyl-*tert*-butylsiloxy)-1-methoxy-ethylene in dry CH_3CN in the presence of a catalytic amount of ZnI_2 (Scheme 2). This reaction, whereby sulfoxides react with *O*-silylated ketene acetals, was studied in some detail by Kita and coworkers as a method for preparing α-siloxy sulfides under mild conditions.[38] The mechanism associated with this process involves the generation of a silyloxy sulfonium salt that undergoes subsequent elimination by a highly stereoselective deprotonation of the antiperiplanar α-methylene proton (Scheme 3).[19,38] In the absence of an internal nucleophile, the silyoxy group is transferred with overall retention of stereochemistry at the sulfur atom. When amidosulfoxide **8** was subjected to the Kita conditions, the initially formed thionium ion reacts exclusively with the proximate amido group to give **9** in high overall yield (94%).

The synthetic value of the Pummerer reaction of an amidosulfoxide such as **8** lies mainly in the subsequent cyclization chemistry of the resulting α-thiophenyl lactam. This led us to study the tandem cyclization cascade of several related amidosulfoxides which possess a π-bond tethered to the amide nitrogen. The silicon-induced Pummerer reaction of the 2-(3,4-dimethoxyphenyl)-substituted amidosulfoxide **10** proceeded uneventfully to provide the expected indolone **11** in 75% yield. Attempts to induce the cyclization of **11** to isoquinoline-dione **12** proved to be unexpectedly difficult, with variable yields of product being obtained. A survey of diverse Lewis acids was carried out ($BF_3{\cdot}OEt_2$, ZnI_2, $AlCl_3$,



Scheme 3.



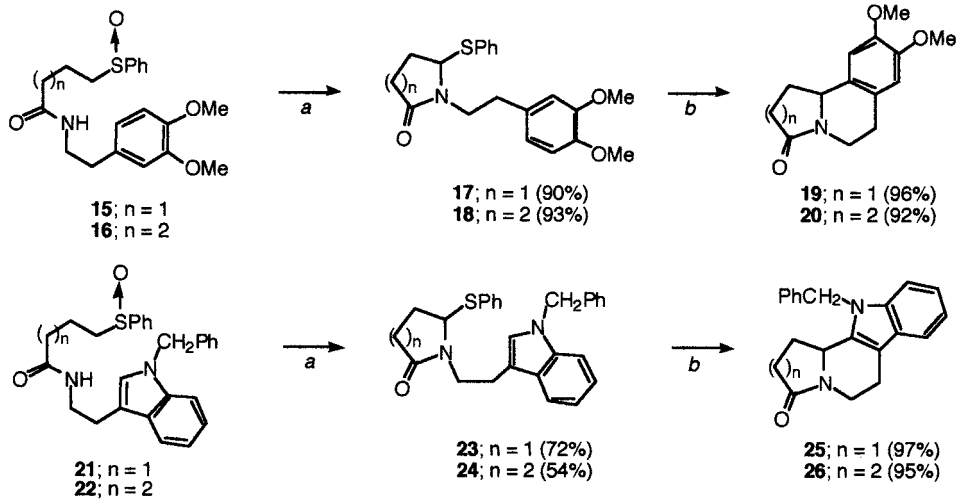
Scheme 4. Reagents: (a) TBDMSOC(OMe)=CH_2, ZnI_2; (b) BF_3·2AcOH; (c) Ac_2O, *p*-TsOH, 110°C.

$TiCl_4$, $MgBr_2$, etc). Among the many Lewis acids employed in this study, $TlCl_3$ in CH_3CN afforded the highest yield of cyclized product **12**, but only in 50% yield. We also examined the Pummerer cyclization of sulfoxide **13** which afforded 3-hydroxypyrrole **14** (50%) as the thermodynamically most stable tautomer. The formation of this product proceeds by an initial cyclization to afford a 3-pyrrolidinone intermediate which is further oxidized upon standing in the presence of air. The isolation of **14** clearly indicates that thionium ion cyclization can also occur with acyclic systems (Scheme 4).

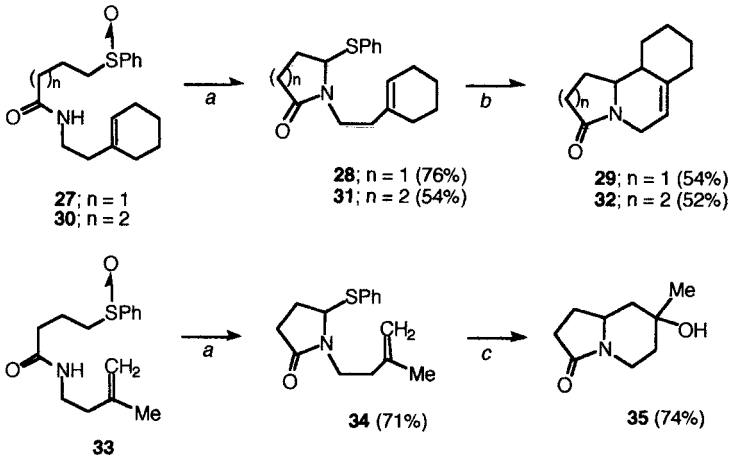
When the acyclic amidosulfoxides **15** and **16** were used, the sequential Pummerer/Mannich cyclization proceeded in excellent yield. These compounds were easily prepared by addition of thiophenol to the appropriate alkenoic acid π-bond,[39] and this was followed by reaction of the in situ generated acyl chloride with 3,4-dimethoxyphenethyl amine. The silicon-induced Pummerer reaction of these amidosulfoxides was carried out using Kita's conditions[38] which led to the very clean formation (>90%) of 2-thio substituted lactams **17** and **18**. Iminium ion-aromatic π-cyclization was readily accomplished by treatment of **17** or **18** with 1.2 equiv. of BF_3·2AcOH in CH_2Cl_2 at 25°C to provide bicyclic lactams **19** or **20** in 96% and 92% yield, respectively (Scheme 5). A related set of reactions occurred using the indolyl substituted amidosulfoxides **21** and **22** which afforded indoles **25** and **26** in excellent yield from the initially formed Pummerer products **23** and **24**.

Since the above examples involve aromatic π-bond cyclization, we decided to study several systems which possess a simple olefinic tether. We found that treatment of the cyclohexenyl substituted amidosulfoxide **27** with the *tert*-butyl *O*-silylated ketene acetal caused an intramolecular Pummerer-type reaction to give α-thiolactam **28** which was subsequently converted to **29** upon exposure to BF_3·2AcOH in 54% overall yield.

The homologous amidosulfoxide **30** also underwent a similar sequence of reactions, first producing **31** which was subsequently converted into isoquinolinone **32**. Extension



Scheme 5. Reagents: (a) TBDMSOC(OMe)=CH_2, ZnI_2; (b) BF_3·2AcOH.

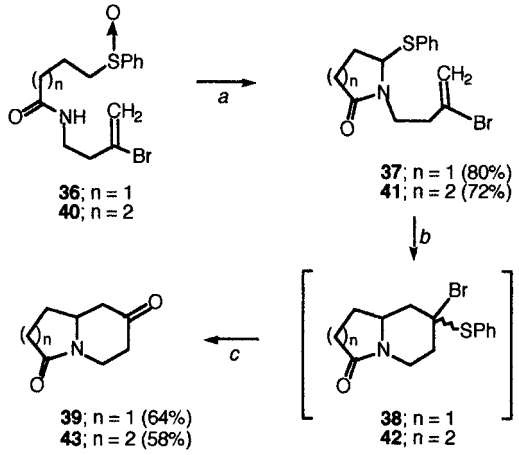


Scheme 6. Reagents: (a) TBDMSOC(OMe)=CH_2, ZnI_2; (b) BF_3·2AcOH; (c) DMTSF.

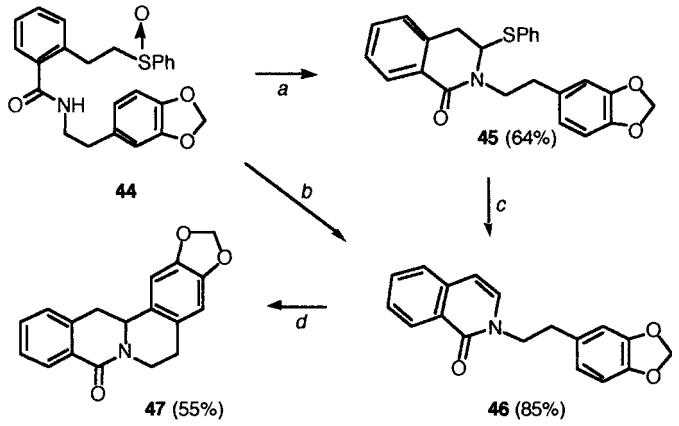
of the two-step cyclization sequence to the 3-methylbutenyl substituted amide **33** was also carried out (Scheme 6). The silicon-induced Pummerer reaction gave rise to the cyclized pyrrolidinone **34** in 71% yield. However, with this system, reaction with BF_3·2AcOH afforded a mixture of several cyclized products that could not be separated by silica gel chromatography. After some experimentation, we found that stirring a sample of thiolactam **34** with dimethyl-(methylthio)sulfonium fluoroborate (DMTSF) proceeded smoothly to give 7-hydroxy-7-methylhexahydroindolizin-3-one (**35**) as the exclusive product in 74% isolated yield. DMTSF is known to exhibit a remarkable thiophilicity for initiation of cyclization reactions of thioketals by promoting thionium ion formation.[40] This reagent also seems to be able to function as a *N*-acyliminium ion promoter when a α-thiophenyl substituted lactam such as **34** is used.

To further explore the scope and generality of the tandem cyclization process, we extended our studies to include the bromoalkenyl substituted amidosulfoxides **36** and **40**. When **36** was subjected to the typical Kita Pummerer conditions, the desired 2-thiolactam **37** was isolated in 80% yield. Further reaction of **37** with BF_3·2AcOH furnished the novel bromo-thiophenyl substituted indolizidine **38** which could be hydrolyzed to ketolactam **39** in good yield (Scheme 7). Similarly, amidosulfoxide **40** was converted into the known octahydroquinolizin-4,8-dione **43**[41] in 58% yield via thiophenyl lactam **41**. These two examples nicely demonstrate the facility with which the *thionium/iminium* ion cascade can occur.

Our interest in establishing amidosulfoxides as useful building blocks for heterocyclic synthesis prompted us to use the Pummerer methodology for the preparation of a member of the protoberberine alkaloid family.[42] The protoberberines are a large class of natural products typically characterized by a tetracyclic ring skeleton with an isoquinoline core.[43] Considerable efforts have been expended in the study of these molecules for both their synthetic and biological significance. These alkaloids exhibit wide-ranging and important biological activity, including antiinflammatory, antileukemic, and antitumor properties.[44] Most of the synthetic approaches are generally plagued by the non-availability of starting materials, multi-step procedures, and moderate to poor yields.[45] A short synthesis of the berberine derivative **47** was carried out as depicted in Scheme 8 in order to highlight the method. This particular compound has been isolated from the Oriental shrub *Acangelissa gusanlung* and given the name gusanlung D.[46] This berberine is one of a number of alkaloids found in the



Scheme 7. Reagents: (a) TBDMSOC(OMe)=CH_2, ZnI_2; (b) BF_3·2AcOH; (c) $Hg(OAc)_2$, HCO_2H.



Scheme 8. Reagents: (a) TMSOTf/NEt_3; (b) TBDMSOC(OMe)=CH_2, ZnI_2; (c) ZnI_2; (d) H^+.

plant, the stem of which has been used in Chinese folk medicine for many years. Subjection of the easily available amidosulfoxide **44** to TMSOTf/NEt_3 as the Pummerer initiator afforded 2-thiophenyl lactam **45** in 64% yield. Interestingly, when the Kita silicon conditions were used to trigger the Pummerer reaction, only enamide **46** (85%) was obtained. The reaction of **45** with Lewis acids such as ZnI_2 resulted in the formation of enamide **46** in 93% yield. When **46** was exposed to acidic conditions, it was transformed into the berberine derivative **47** in 55% yield.

The method used to generate *N*-acyliminium ions is often critical to the success of the subsequent cyclization chemistry, as many of the nucleophiles employed for typical Mannich cyclizations can be easily destroyed under the reaction conditions. Thus, iminium ion formation is often guided by the need to tailor the reaction conditions to the specific characteristics of the starting molecule and to those of the intended target. Most often, the *N*-acyliminium precursor is generated from either the condensation of an amide and an aldehyde, or from the reduction of an imide. A limitation of the first method is that it is an equilibrium process which usually favors the reactants. Thus, this process is confined to highly reactive aldehydes and to intramolecular variants. The partial reduction of an imide can suffer from regio- and stereoselectivity problems when unsymmetrical imides are utilized. In addition, the choice of reducing agents and reaction conditions must be made with care, as overreduction and/or ring opening often occurs. Although many methods have been developed to circumvent these problems, most add synthetic complexity to the process. In many cases, Mannich cyclizations are performed under harsh conditions which limit their utility when the cyclizations are carried out in the presence of sensitive functional groups. Thus, there is a continuing need to develop alternative methods to generate these exceedingly useful synthetic intermediates. The studies outlined above demonstrate that the thionium/*N*-acyliminium ion cyclization sequence of amidosulfoxides represents a highly efficient and mild method for the synthesis of azapolycyclic ring systems. The further utilization of this cyclization cascade for the stereocontrolled synthesis of a variety of perhydroindole alkaloids is under current investigation and will be reported at a later date.

Experimental

Melting points are uncorrected. Mass spectra were determined at an ionizing voltage of 70 eV. Unless otherwise noted, all reactions were performed in flame dried glassware under an atmosphere of dry argon. Solutions were evaporated under reduced pressure with a rotary evaporator and the residue was chromatographed on a silica gel column using an ethyl acetate/hexane mixture as the eluent unless specified otherwise. All solids were recrystallized from ethyl acetate/hexane for analytical data.

Standard procedure for the preparation of amidosulfoxides

To a solution containing 1 mmol of the appropriate carboxylic acid and 15 mL of CH_2Cl_2 was added 1 mL of a 2.0 M solution (2 mmol) of oxalyl chloride. To this solution was added 3 drops of DMF. The reaction was allowed to stir at rt for 2 h and the solvent and excess oxalyl chloride were removed under reduced pressure. The residue was taken up in 15 mL of CH_2Cl_2 and cooled to 0°C. To this solution was slowly added 1.1 mmol of the amine followed by 1.1 mmol of triethylamine The reaction mixture was allowed to warm to 25°C, stirred for 1 h and then diluted with water. The mixture was extracted with CH_2Cl_2 and the combined extracts were dried over $MgSO_4$. The solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give the amidosulfide.

To a solution containing 1.0 mmol of the above sulfide and 25 mL of methanol was added a solution containing 1.5 mmol of $NaIO_4$ and 25 mL water. The mixture was allowed to stir at rt for 24 h and was diluted with water and extracted with CH_2Cl_2. The combined organic layers were dried over $MgSO_4$. The solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give the amidosulfoxide.

1-Acetyl-2-methylsulfanyl-1,2-dihydroindol-3-one (9). A solution containing 0.2 g (0.84 mmol) of *N*-((2-methanesulfinyl)acetylphenyl)acetamide (**8**)[36], 0.8 mL (3.5 mmol) of acetic anhydride, 20 mg of *p*-TsOH, and 15 mL of toluene was heated at reflux for 2.5 h. The reaction mixture was cooled and the solvent was removed under reduced

pressure. The residue was subjected to silica gel chromatography to give 0.18 g (94%) of **9** as a white solid: mp 83–84°C; IR ($CHCl_3$) 1721, 1680, and 1612 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 2.01 (s, 3H), 2.54 (s, 3H), 5.01 (brs, 1H), 7.24 (t, 1H, J=7.5 Hz); 7.68 (td, 1H, J=7.5 and 1.2 Hz), 7.76 (d, 1H, J=7.5 Hz), and 8.48 (brs, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 10.9, 24.5, 65.4, 118.4, 123.6, 124.2, 124.8, 137.8, 152.8, 169.2, and 194.6; Anal. Calcd for $C_{11}H_{11}NSO_2$: C, 59.71; H, 5.01; N, 6.33. Found: C, 59.64; H, 5.03; N, 6.30.

2-Ethylsulfanyl-1-(2-nitrophenyl)ethanone. To a solution containing 6.6 g (0.12 mol) of KOH in 150 mL of H_2O at 0°C was added 6.8 mL (0.09 mol) of ethanethiol. After stirring at 0°C for 30 min, a solution containing 20 g (0.08 mol) of *o*-nitrophenacyl bromide[47] in 200 mL of ether was added. The mixture was stirred vigorously for 5 h, the organic layer was separated, and the aqueous layer was extracted with ether. The combined organic layers were washed with a saturated ammonium chloride solution and dried over $MgSO_4$. The solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give 17.0 g (90%) of the title compound as an orange oil: IR (neat) 3105, 1697, and 1524 cm^{-1}; ^1H NMR ($CDCl_3$, 300 MHz) δ 1.29 (t, 3H, J=7.1 Hz), 2.62 (q, 2H, J=7.1 Hz), 3.65 (s, 2H), 7.55 (d, 1H, J=7.6 Hz), 7.63 (t, 1H, J=7.6 Hz), 7.75 (t, 1H, J=7.6 Hz), and 8.12 (d, 1H, J=7.6 Hz); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 14.0, 26.3, 40.5, 124.3, 129.5, 130.7, 134.1, 136.2, 150.1, and 196.4; Anal. Calcd for $C_{10}H_{11}NO_3S$: C, 53.32; H, 4.93; N, 6.22. Found: C, 53.58; H, 4.86; N, 6.01.

1-(2-Aminophenyl)-2-(ethylsulfanyl)ethanone. To a solution containing 5.0 g (22 mmol) of the above sulfide in 120 mL of THF at 0°C was added 42 g (0.2 mol) of $SnCl_2$ in 50 mL of concentrated HCl. The mixture was stirred at 25°C for 3 h and quenched by the addition of 150 mL of a 50% aqueous NaOH solution. After stirring for an additional 1 h, the mixture was extracted with ethyl acetate. The combined organic layers were washed with brine, dried over $MgSO_4$, and concentrated under reduced pressure. The residue was subjected to silica gel chromatography to give 4.1 g (95%) of the title compound as a yellow oil: IR (neat) 3468, 1636, and 1245 cm^{-1}; ^1H NMR ($CDCl_3$, 300 MHz) δ 1.28 (t, 3H, J=7.4 Hz), 2.63 (q, 2H, J=7.4 Hz), 3.81 (s, 2H), 6.28 (brs, 2H), 6.62–6.68 (m, 2H), 7.27 (t, 1H, J=8.1 Hz), and 7.71 (d, 1H, J=8.1 Hz); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 14.4, 26.6, 38.2, 115.8, 116.2, 117.6, 131.7, 134.7, 151.3, and 197.4; Anal. Calcd for $C_{10}H_{13}NOS$: C, 61.52; H, 6.72; N, 7.18. Found: C, 61.42; H, 6.69; N, 7.13.

2-(3,4-Dimethoxyphenyl)-*N*-((2-ethylsulfanyl)acetylphenyl)acetamide. To a solution containing 2.0 g (10 mmol) of the above aniline in 50 mL of THF was added a solution containing 2.5 g (11 mmol) of 3,4-dimethoxyphenylacetic acid chloride in 20 mL of THF followed by 1.7 mL (12 mmol) of triethylamine. The solution was allowed to stir at 25°C for 5 h and was poured into water. The mixture was extracted with ethyl acetate and the combined organic layers were washed with brine and dried over $MgSO_4$. The solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give 3.6 g (94%) of the title compound as a white solid: mp 79–80°C; IR ($CHCl_3$) 3250, 1654, and 1510 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.25 (t, 3H, J=7.2 Hz), 2.53 (q, 2H, J=7.2 Hz), 3.70 (s, 2H), 3.78 (s, 2H), 3.88 (s, 3H), 3.92 (s, 3H), 6.85–6.95 (m, 3H), 7.09 (td, 1H, J=7.5 and 1.2 Hz), 7.54 (td, 1H, J=7.5 and 1.2 Hz), 7.83 (dd, 1H, J=8.0 and 1.2 Hz), 8.76 (dd, 1H, J=8.0 and 1.2 Hz), and 11.57 (s, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 14.1, 26.5, 38.3, 45.6, 55.8, 55.9, 111.4, 112.5, 120.2, 121.0, 121.7, 122.4, 126.8, 131.2, 135.3, 141.8, 148.3, 149.1, 170.8, and 198.8; Anal. Calcd for $C_{20}H_{23}NSO_4$: C, 64.32; H, 6.21; N, 3.78. Found: C, 64.43; H, 6.15; N, 3.78.

2-(3,4-Dimethoxyphenyl)-*N*-((2-ethylsulfinyl)acetylphenyl)acetamide (10). Using the standard procedure, a 2.7 g (7 mmol) sample of the above sulfide and 2.4 g (11 mmol) of $NaIO_4$ in 200 mL of a 1:1-methanol/water mixture gave 2.7 g (93%) of **10** as a white solid: mp 115–116°C; IR ($CHCl_3$) 3263, 1688, and 1510 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.39 (t, 3H, J=7.6 Hz), 2.76–2.83 (m, 1H), 2.85–2.92 (m, 1H), 3.70 (s, 2H), 3.88 (s, 3H), 3.91 (s, 3H), 4.23 (d, 1H, J=14.4 Hz), 4.37 (d, 1H, J=14.4 Hz), 6.86–6.94 (m, 3H), 7.14 (td, 1H, J=7.8 and 1.2 Hz), 7.59 (td, 1H, J=7.8 and 1.2 Hz), 7.85 (dd, 1H, J=8.0 and 1.2 Hz), 8.76 (dd, 1H, J=8.0 and 1.2 Hz), and 11.57 (s, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 6.7, 46.7, 46.3, 56.0, 56.0, 60.8, 111.6, 112.7, 121.0, 121.4, 121.9, 122.9, 126.6, 132.0, 136.5, 141.6, 148.5, 149.3, 171.0, and 195.7; Anal. Calcd for $C_{20}H_{23}NSO_5$: C, 61.68; H, 5.96; N, 3.59. Found: C, 61.66; H, 5.95; N, 3.59.

1-[(3,4-Dimethoxyphenyl)acetyl]-2-ethylsulfanyl-1,2-dihydroindol-3-one (11). A solution containing 0.3 g (0.8 mmol) of sulfoxide **10**, 0.4 mL (4.0 mmol) of acetic anhydride, 0.02 g (0.08 mmol) of *p*-toluenesulfonic acid and 15 mL of xylene was heated at 125°C for 2 h. After cooling to rt, the solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give 0.2 g (75%) of **11** as a white solid: mp 103–104°C; IR ($CHCl_3$) 2933, 1699, and 1588 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.22 (t, 3H, J=7.6 Hz), 2.50–2.58 (m, 1H), 2.61–2.70 (m, 1H), 3.85 (s, 3H), 3.86 (s, 3H), 4.18 (s, 2H), 5.09 (s, 1H), 6.82–6.86 (m, 3H), 7.23 (td, 1H, J=8.0 and 0.8 Hz), 7.65 (td, 1H, J=7.6 and 1.6 Hz), 7.73 (dd, 1H, J=7.6 and 0.8 Hz), and 8.51 (brd, 1H, J=8.0 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 15.3, 23.6, 43.6, 56.9, 57.0, 64.8, 112.5, 113.3, 119.6, 122.4, 124.2, 125.1, 125.9, 127.0, 138.6, 149.4, 150.2, 153.6, 171.0, and 195.6; Anal. Calcd for $C_{20}H_{21}NSO_4$: C, 64.67; H, 5.70; N, 3.77. Found: C, 64.91; H, 5.75; N, 3.80.

2,3-Dimethoxy-5,12*a*-dihydroindolo[2,1-*a*]isoquinoline-6,12-dione (12). To a solution containing 0.06 g (0.2 mmol) of indoline **11**, 3 mL of acetonitrile, and 1 mL of methanol was added 0.04 g (0.3 mmol) of $TiCl_3$ in 0.3 mL of water. To this mixture was added 0.09 mL of 30% aqueous H_2O_2. The resulting red solution was stirred for 15 h at 25°C and was quenched by the addition of 15 mL of water. The reaction mixture was extracted with $CHCl_3$ and the combined organic layer was dried over $MgSO_4$ and concentrated under reduced pressure. The resulting residue was subjected to silica gel chromatography to give 0.04 g (50%) of **12**: mp 136–138°C; IR ($CHCl_3$) 3285, 1737, and 1683 cm^{-1}; ^1H

NMR ($CDCl_3$, 400 MHz) δ 3.48 (s, 1.5H), 3.88 (s, 1.5H), 3.89 (s, 1H), 3.91 (s, 1.5H), 3.97 (s, 1.5H), 4.06 (s, 1 H), 5.37 (s, 0.5H), 6.85 (s, 0.5H), 6.90 (s, 0.5H), 6.91 (s, 0.5H), 6.4 (s, 0.5H), 7.14 (t, 0.5H, J=8.0 Hz), 7.24 (t, 0.5H, J=8.0 Hz), 7.61–7.70 (m, 1.5H), 7.75 (d, 0.5H, J=8.0 Hz), 8.52 (d, 0.5H, J=8.0 Hz), 8.81 (d, 0.5H, J=8.0 Hz), and 11.02 (brs, 0.5H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 39.9, 43.1, 52.9, 53.1, 56.3, 56.4, 86.1, 112.7, 113.0, 114.2, 114.3, 117.6, 118.4, 121.1, 122.7, 123.0, 123.7, 124.0, 124.3, 124.9, 125.7, 126.1, 133.7, 137.2, 138.6, 142.5, 148.1, 149.1, 149.4, 153.5, 164.2, 169.8, 169.9, 190.0, and 195.2; Anal. Calcd for $C_{18}H_{15}NO_4$: C, 69.89; H, 4.89; N, 4.53. Found: C, 69.61; H, 4.73; N, 4.31.

***N*-(4-Methanesulfinyl-3-oxobutyl)benzamide (13).** To a solution containing 8 mL of DMSO and 10 mL of THF was added 0.9 g (21 mmol) of 60% NaH in mineral oil. The mixture was heated at 70°C for 30 min, then cooled to 0°C and a solution containing 1.5 g (7.1 mmol) of 3-benzoylaminopropionic acid methyl ester and 5 mL of DMSO was added. The reaction mixture was allowed to warm to rt, stirred for 1 h, and quenched by the addition of a saturated aqueous $NaHCO_3$ solution. The mixture was extracted with CH_2Cl_2 and the combined extracts were dried over $MgSO_4$. The solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give 0.99 g (55%) of **13** as a white solid: mp: 139–141°C; IR ($CHCl_3$) 3298, 1695, and 1648 cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 2.70 (s, 3H), 2.91–3.08 (m, 2H), 3.63 (d, 1H, J=13.4 Hz), 3.38–3.83 (m, 1H), 3.93 (d, 1H, J=13.4 Hz), 6.90 (brs, 1H), 7.42 (tt, 2H, J=7.2 and 1.2 Hz), 7.49 (tt, 1H, J=7.2 and 1.2 Hz), and 7.76 (dt, 2H, J=7.2 and 1.2 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 34.8, 39.0, 45.4, 63.2, 127.2, 128.8, 131.7, 134.3, 167.6, and 202.5; Anal. Calcd for $C_{12}H_{15}SNO_3$: C, 56.90; H, 5.97; N, 5.53. Found: C, 56.76; H, 5.94; N, 5.41.

(3-Hydroxy-2-methylsulfanyl-pyrrol-1-yl)phenylmethanone (14). A solution containing 0.17 g (0.66 mmol) of sulfoxide **13**, 0.6 mL (6.6 mmol) of acetic anhydride, 10 mg of *p*-TsOH, and 15 mL of toluene was heated at reflux for 3 h. The reaction mixture was allowed to cool to rt and the solvent was removed under reduced pressure. The residue was subjected to silica gel chromatography to give 0.08 g (50%) of **14** as a white solid: mp 60–62°C; IR ($CHCl_3$) 3152, 1763, and 1690 cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 2.24 (s, 3H), 6.26–6.28 (m, 1H), 7.16 (t, 1H, J=3.2 Hz), 7.37–7.38 (m, 1H), 7.50 (t, 2H, J=7.6 Hz), 7.60 (t, 1H, J=7.6 Hz), and 7.73 (d, 2H, J=7.6 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 21.1, 107.6, 109.9, 119.4, 128.7, 129.6, 132.5, 140.4, 167.5, and 168.5; Anal. Calcd for $C_{12}H_{11}NSO_2$: C, 61.79; H, 4.76; N, 6.01. Found: C, 61.59; H, 4.61; N, 5.85.

***N*-[2-(3,4-Dimethoxyphenyl)ethyl]-4-(phenylsulfanyl)-butyramide.** Using the standard procedure, a 1.0 g (5.1 mmol) sample of 4-(phenylthio)butyric acid,[39] 5 mL of a 2.0 M solution (10 mmol) of oxalyl chloride, and 2.5 mL (7.5 mmol) of 3,4-dimethoxy-phenethylamine in 50 mL of CH_2Cl_2 gave 1.8 g (99%) of the title compound as a white solid: mp 98–99°C; IR ($CHCl_3$) 3296, 1642, and 1510 cm^{-1}; ^{1}H NMR ($CDCl_3$, 300 MHz) δ 1.93 (quint, 2H, J=9.2 Hz), 2.26 (t, 2H, J=9.6 Hz), 2.72 (t, 2H, J=9.2 Hz), 2.92 (t, 2H, J=9.2 Hz), 3.47 (dd, 2H, J=13.0 and 9.2 Hz), 3.80 (s, 3H), 3.85 (s, 3H), 5.43 (brs, 1H), 6.67–6.78 (m, 3H), 7.15 (t, 1H, J=7.0 Hz), and 7.23–7.31 (m, 4H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 24.8, 33.0, 34.9, 35.3, 40.7, 55.9, 55.9, 108.5, 111.3, 111.8, 120.6, 126.0, 128.9, 129.2, 131.2, 147.7, and 149.1; Anal. Calcd for $C_{20}H_{25}NSO_3$: C, 66.82; H, 7.02; N, 3.90. Found: C, 66.93; H, 7.09; N, 3.95.

4-Benzenesulfinyl-*N*-[2-(3,4-dimethoxyphenyl)ethyl]-butyramide (15). Using the standard procedure, a 1.8 g (5.0 mmol) sample of the above sulfide and 1.6 g (7.5 mmol) of $NaIO_4$ in 100 mL of a 1:1-methanol/water mixture gave 1.7 g (92%) of **15** as a white solid: mp 87–88°C; IR ($CHCl_3$) 3303, 1649, and 1510 cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 1.92–2.01 (m, 2H), 2.52–2.34 (m, 2H), 2.71–2.77 (m, 3H), 2.82 (m, 1H), 3.46 (qd, 2H, J=7.2 and 1.6 Hz), 3.82 (s, 3H), 3.83 (s, 3H), 5.92 (brs, 1H), 6.68–6.69 (m, 2H), 6.75–6.77 (m, 1H), 7.46–7.51 (m, 3H), and 7.53 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 19.1, 34.9, 35.4, 40.8, 55.8, 56.0, 56.1, 111.4, 111.9, 120.8, 124.1, 129.5, 131.2, 131.4, 143.5, 147.8, 149.2, and 171.6; Anal. Calcd for $C_{20}H_{25}NSO_4$: C, 63.97; H, 6.72; N, 3.73. Found: C, 63.85; H, 6.74; N, 3.67.

1-[2-(3,4-Dimethoxyphenyl)ethyl]-5-phenylsulfanyl-pyrrolidin-2-one (17). To a solution containing 0.2 g (0.5 mmol) of sulfoxide **15** and 20 mL of acetonitrile was added 0.02 g (0.05 mmol) of ZnI_2, followed by 0.2 g (1 mmol) of *tert*-butyl-1-(methoxyvinyloxy)dimethylsilane.[38] The solution was stirred at rt for 1 h and was quenched by the addition of 20 mL of a saturated $NaHCO_3$ solution. The mixture was extracted with CH_2Cl_2, and the combined organic layers were dried over $MgSO_4$. The solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give 0.19 g (98%) of **17** as a white solid: mp 80–81°C; IR ($CHCl_3$) 3058, 1695, and 1589 cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 1.60 (dt, 1H, J=17.2 and 9.6 Hz), 1.94–2.08 (m, 2H), 2.19–2.29 (m, 1H), 2.69–2.78 (m, 2H), 3.38 (dt, 1H, J=13.2 and 7.6 Hz), 3.77 (s, 3H), 3.78 (s, 3H), 3.96 (quint, 1H, J=7.2 Hz), 4.49 (dd, 1H, J=8.0 and 1.6 Hz), 6.61–6.64 (m, 2H), 6.70 (d, 1H, J=8.0 Hz), and 7.27–7.31 (m, 5H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 26.7, 29.1, 33.2, 41.7, 55.8, 55.9, 67.8, 111.2, 111.7, 120.6, 128.9, 129.2, 130.7, 131.1, 135.0, 147.6, 148.8, and 174.4; Anal. Calcd for $C_{20}H_{23}NSO_3$: C, 67.20; H, 6.49; N, 3.92. Found: C, 67.00; H, 6.47; N, 3.98.

8,9-Dimethoxy-1,5,6,10*b*-tetrahydro-2*H*-pyrrolo[2,1-*a*]-isoquinolin-3-one (19). To a solution containing 0.2 g (0.56 mmol) of sulfide **17** and 15 mL of CH_2Cl_2 was added 0.15 mL (1.1 mmol) of $BF_3{\cdot}2AcOH$. The solution was stirred at rt for 3 h, quenched by the addition of 2 mL of methanol, and poured into water and extracted with CH_2Cl_2. The combined organic layers were dried over $MgSO_4$ and concentrated under reduced pressure. The residue was subjected to silica gel chromatography to give 0.13 g (96%) of **19** as a white solid: mp 97–99°C (lit.[48] mp 98–99°C); IR ($CHCl_3$) 1682, 1609, and 1517 cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 1.77 (quint, 1H, J=10.0 Hz), 2.36–2.43 (m, 1H), 2.47–2.64 (m, 3H), 2.78–2.86 (m,

1H), 2.95 (td, 1H, *J*=12.8 and 4.4 Hz), 3.80 (s, 3H), 3.81 (s, 3H), 4.23 (ddd, 1H, *J*=12.8, 6.0, and 2.0 Hz), 4.67 (t, 1H, *J*=8.0 Hz), 6.52 (s, 1H), and 6.56 (s, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 27.8, 28.1, 31.8, 37.0, 55.9, 56.0, 56.5, 107.6, 111.6, 125.5, 129.3, 147.8, 148.0, and 173.1; Anal. Calcd for $C_{14}H_{17}NO_3$: C, 68.00; H, 6.93; N, 5.66. Found: C, 67.92; H, 6.85; N, 5.46.

***N*-[2-(3,4-Dimethoxyphenyl)ethyl]-5-(phenylsulfanyl)-pentanamide.** Using the standard procedure, a 1.0 g (4.8 mmol) sample of 5-(phenylthio)pentanoic acid,[49] 3.5 mL of a 2.0 M solution (7.0 mmol) of oxalyl chloride in CH_2Cl_2, and 2.4 mL (7.0 mmol) of 3,4-dimethoxyphenethylamine in 45 mL of CH_2Cl_2 gave 1.4 g (79%) of the title compound as a white solid: mp 69–70°C; IR ($CHCl_3$) 3303, 1642, and 1517 cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 1.64 (m, 2H), 1.74 (m, 2H), 2.12 (t, 2H, *J*=7.2 Hz), 2.73 (t, 2H, *J*=7.2 Hz), 2.90 (t, 2H, *J*=7.2 Hz), 3.47 (dd, 2H, *J*=12.8 and 7.0 Hz), 3.84 (s, 3H), 3.85 (s, 3H), 5.46 (brs, 1H), 6.69–6.71 (m, 2H), 6.78–6.80 (m, 1H), 7.15 (tt, 1H, *J*=6.8 and 1.6 Hz), and 7.24–7.31 (m, 4H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 25.9, 29.7, 34.3, 36.3, 37.2, 41.7, 56.9, 57.0, 122.3, 112.8, 126.9, 129.9, 130.0, 132.4, 137.6, 148.7, 150.0, and 173.5; Anal. Calcd for $C_{21}H_{27}NSO_3$: C, 67.53; H, 7.29; N, 3.76. Found: C, 67.62; H, 7.35; N, 3.76.

***N*-[2-(3,4-Dimethoxyphenyl)ethyl]-5-(benzenesulfinyl)-pentanamide (16).** Using the standard procedure, a 1.1 g (2.0 mmol) sample of the above sulfide and 0.7 g (3.0 mmol) of $NaIO_4$ in 100 mL of a 1:1-methanol/water mixture gave 1.07 g (95%) of **16** as a white solid: mp 91–92°C; IR ($CHCl_3$) 3310, 1652, and 1524 cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 1.59–1.81 (m, 4H), 2.13 (td, 2H, *J*=7.2 and 2.0 Hz), 2.70–2.78 (m, 4H), 3.46 (dd, 2H, *J*=12.8 and 7.2 Hz), 3.83 (s, 3H), 3.84 (s, 3H), 5.76 (brt, 1H, *J*=5.2 Hz), 6.69–6.71 (m, 2H), 6.77–6.79 (m, 1H), 7.47–7.52 (m, 3H), and 7.57–7.59 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 21.7, 24.5, 35.1, 35.6, 40.6, 55.6, 55.7, 56.6, 111.1, 111.7, 120.4, 123.7, 129.1, 130.9, 131.3, 143.3, 147.3, 148.7, and 172.1; Anal. Calcd for $C_{21}H_{27}NSO_4$: C, 64.76; H, 6.99; N, 3.60. Found: C, 64.73; H, 7.05; N, 3.58.

1-[2-(3,4-Dimethoxyphenyl)ethyl]-6-phenylsulfanyl-piperidin-2-one (18). To a solution containing 0.2 g (0.5 mmol) of sulfoxide **16** and 20 mL of acetonitrile was added 0.02 g (0.05 mmol) of ZnI_2 followed by 0.19 g (1.0 mmol) of *tert*-butyl-1-(methoxyvinyloxy)dimethylsilane. The solution was stirred at rt for 12 h and was quenched by the addition of 20 mL of a saturated $NaHCO_3$ solution. The mixture was extracted with CH_2Cl_2 and the combined organic layers were dried over $MgSO_4$. The solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give 0.18 g (93%) of **18** as a colorless oil: IR (neat) 2933, 1657, and 1511 cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 1.68–1.82 (m, 2H), 1.90–1.94 (m, 2H), 2.13–2.56 (m, 3H), 2.84–2.87 (m, 2H), 3.30–3.37 (m, 1H), 3.84 (s, 3H), 3.85 (s, 3H), 4.20–4.23 (m, 1H), 4.35–4.36 (m, 1H), 6.69–6.73 (m, 2H), 6.77–6.81 (m, 1H), and 7.28–7.31 (m, 5H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 17.2, 29.7, 32.2, 33.7, 48.4, 56.0, 56.1, 69.8, 111.4, 111.5, 112.1, 121.0, 128.3, 129.4, 132.1, 133.6, 147.8, 149.1, and 170.0; Anal. Calcd for $C_{21}H_{25}NSO_3$: C, 67.90; H, 6.78; N, 3.77. Found: C, 67.77; H, 6.81; N, 3.79.

9,10-Dimethoxy-1,2,3,6,7,11*b*-hexahydro-pyrrido[2,1-*a*]isoquinolin-4-one (20). To a solution containing 0.2 g (0.5 mmol) of sulfide **18** and 15 mL of CH_2Cl_2 was added 0.15 mL (1.1 mmol) of BF_3·2AcOH. The reaction mixture was stirred at rt for 3 h and was quenched by the addition of 2 mL of methanol. The mixture was poured into water, extracted with CH_2Cl_2 and the combined organic layers were dried over $MgSO_4$ and concentrated under reduced pressure. The resulting residue was subjected to silica gel chromatography to give 0.12 g (92%) of **20** as a white solid: mp 88 –90°C (lit.[48] mp 89–90°C); IR ($CHCl_3$) 1638, 1510, and 1446 cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 1.58–1.69 (m, 1H), 1.76–1.87 (m, 1H), 1.88–1.96 (m, 1H), 2.29–2.38 (m, 1H), 2.48–2.63 (m, 3H), 2.74–2.91 (m, 2H), 3.84 (s, 3H), 3.85 (s, 3H), 4.58 (dd, 1H, *J*=10.8 and 4.4 Hz), 4.85 (ddd, 1H, *J*=12.0, 4.4, and 2.0 Hz), 6.59 (s, 3H), and 6.65 (s, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 19.7, 28.6, 31.1, 32.3, 39.8, 56.0, 56.2, 56.8, 108.3, 111.6, 127.4, 129.2, 147.8, 147.9, and 169.4; Anal. Calcd for $C_{15}H_{19}NO_3$: C, 68.93; H, 7.33; N, 5.36. Found: C, 68.85; H, 7.18; N, 5.26.

***N*-[2-(1-Benzyl-1*H*-indol-3-yl)ethyl]-4-(phenylsulfanyl)-butyramide.** Using the standard procedure, a 1.0 g (5.1 mmol) sample of 4-(phenylthio)butyric acid,[39] 5 mL of a 2.0 M solution (10 mmol) of oxalyl chloride in 10 mL of CH_2Cl_2, 1.3 g (5.1 mmol) of 2-(1-benzyl-1*H*-indol-3-yl)ethylamine,[50] and 0.8 mL (5.6 mmol) of triethylamine in 45 mL of CH_2Cl_2 gave 1.7 g (75%) of the title compound as a yellow solid: mp 104–105°C; IR ($CHCl_3$) 3312, 1644, and 1550 cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 1.93 (quint, 2H, *J*=7.2 Hz), 2.23 (t, 2H, *J*=7.2 Hz), 2.94 (m, 4H), 3.58 (dd, 2H, *J*=12.8 and 6.5 Hz), 5.26 (s, 2H), 5.48 (brs, 1H), 6.93 (s, 1H), 7.10–7.32 (m, 13H), and 7.60 (d, 1H, *J*=7.6 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 25.0, 25.5, 33.1, 35.1, 39.9, 50.1, 110.0, 112.3, 119.2, 119.5, 122.2, 126.2, 126.3, 127.0, 127.9, 128.2, 129.0, 129.1, 129.4, 137.0, 137.8, 144.1, and 172.1; Anal. Calcd for $C_{27}H_{28}N_2SO$: C, 75.67; H, 6.59; N, 6.54. Found: C, 75.61; H, 6.64; N, 6.64.

4-Benzenesulfinyl-*N*-[2-(1-benzyl-1*H*-indol-3-yl)ethyl]-butyramide (21). Using the standard procedure, a 0.9 g (2.0 mmol) sample of the above sulfide and 0.7 g (3.0 mmol) of $NaIO_4$ in 100 mL of a 1:1-methanol/water mixture gave 0.8 g (81%) of **21** as a yellow solid: mp 117–118°C; IR ($CHCl_3$) 3298, 1650, and 1544 cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 1.92–2.01 (m, 1H), 2.03–2.10 (m, 1H), 2.20–2.31 (m, 2H), 2.72–2.87 (m, 1H), 2.96 (t, 2H, *J*=6.5 Hz), 3.58 (q, 2H, *J*=6.5 Hz), 5.27 (s, 2H), 5.75 (brs, 1H), 6.96 (s, 1H), 7.12 (t, 2H, *J*=7.6 Hz), 7.19 (t, 1H, *J*=7.6 Hz), 7.25–7.29 (m, 5H), 7.46–7.49 (m, 3H), 7.53–7.56 (m, 2H), and 7.60 (d, 1H, *J*=8.0 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 19.1, 25.5, 35.0, 39.9, 50.1, 56.0, 110.0, 112.3, 119.1, 119.5, 122.2, 124.1, 126.3, 127.1, 127.9, 128.2, 129.0, 129.5, 131.2, 137.0, 137.7, 143.7, and 171.5; Anal. Calcd for $C_{27}H_{28}N_2SO_2$: C, 72.94; H, 6.35; N, 6.30. Found: C, 72.91; H, 6.40; N, 6.27.

1-[2-(1-Benzyl-1*H*-indol-3-yl)ethyl]-5-phenylsulfanyl-pyrrolidin-2-one (23). To a solution containing 0.6 g

(1.4 mmol) of sulfoxide **21** in 40 mL of acetonitrile was added 0.04 g (0.1 mmol) of ZnI_2 followed by 0.5 g (3.0 mmol) of *tert*-butyl-1-(methoxyvinyloxy)dimethylsilane. The solution was stirred at 25°C for 4 h and was quenched by the addition of 30 mL of a saturated $NaHCO_3$ solution. The mixture was extracted with CH_2Cl_2 and the combined organic layers were dried over $MgSO_4$. The solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give 0.4 g (72%) of **23** as a yellow oil: IR (neat) 1683, 1404, and 1251 cm^{-1}, ^1H NMR ($CDCl_3$, 400 MHz) δ 1.65–1.75 (m, 1H), 1.94–2.06 (m, 3H), 2.94–3.07 (m, 2H), 3.56 (dt, 1H, J=13.6 and 7.2 Hz), 4.05–4.12 (m, 1H), 4.46 (dd, 1H, J=7.2 and 2.0 Hz), 5.14 (d, 1H, J=16.0 Hz), 5.18 (d, 1H, J=16.0 Hz), 6.88 (s, 1H), 7.00–7.02 (m, 1H), 7.09–7.27 (m, 11H), and 7.62 (d, 1H, J=8.0 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 23.3, 26.7, 29.1, 40.9, 49.7, 68.2, 109.7, 112.1, 119.0, 119.2, 122.0, 125.9, 126.7, 127.6, 127.9, 128.7, 128.8, 129.2, 130.8, 135.0, 136.6, 137.6, and 174.5; HRMS Calcd for $C_{27}H_{26}N_2SO$: 426.1766. Found: 426.1765.

11-Benzyl-1,2,5,6,11,11*b*-hexahydroindolizino[8,7-*b*]indol-3-one (25). To a solution containing 0.2 g (0.5 mmol) of sulfide **23** in 20 mL of CH_2Cl_2 was added 0.2 mL (1.0 mmol) of $BF_3{\cdot}2AcOH$. The mixture was stirred at 25°C for 15 min and was quenched by the addition of 2 mL of methanol. The solution was poured into water, extracted with CH_2Cl_2 and the combined organic layer was dried over $MgSO_4$ and concentrated under reduced pressure. The residue was subjected to silica gel chromatography to give 0.14 g (97%) of **25** as a white solid mp 71–72°C; IR ($CHCl_3$) 2926, 1690, and 1424 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.77–1.88 (m, 1H), 2.40–2.58 (m, 3H), 2.86–2.98 (m, 3H), 4.55 (dt, 1H, J=12.8 and 3.0 Hz), 4.81 (t, 1H, J=6.8 Hz), 5.28 (d, 1H, J=17.2 Hz), 5.38 (d, 1H, J=17.2 Hz), 6.96 (dd, 2H, J=8.4 and 2.0 Hz), 7.15–7.29 (m, 6H), and 7.55 (dd, 1H, J=6.8 and 1.6 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 21.6, 27.1, 31.9, 37.9, 47.6, 54.5, 108.8, 109.7, 118.8, 120.0, 122.4, 126.0, 127.8, 129.1, 134.7, 137.4, 137.5, and 173.1; Anal. Calcd for $C_{21}H_{20}N_2O$: C, 79.72; H, 6.37; N, 8.85. Found: C, 79.84; H, 6.51; N, 8.81.

***N*-[2-(1-Benzyl-1*H*-indol-3-yl)ethyl]-5-(phenylsulfanyl)-pentanamide.** Using the standard procedure, a 1.0 g (5 mmol) sample of 5-(phenylthio)pentanoic acid,[49] 3.5 mL of a 2.0 M solution (7.0 mmol) of oxalyl chloride in CH_2Cl_2, 1.3 g (5 mmol) of 2-(1-benzyl-1*H*-indol-3-yl)ethylamine,[50] and 0.8 mL (5.6 mmol) of triethylamine in 45 mL of CH_2Cl_2 gave 1.6 g (69%) of the title compound as a yellow solid: mp 74–75°C; IR ($CHCl_3$) 3298, 1644, and 1544 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.57–1.64 (m, 2H), 1.66–1.73 (m, 2H), 2.06 (t, 2H, J=7.4 Hz), 2.86 (t, 2H, J=7.4 Hz), 2.93 (t, 2H, J=6.4 Hz), 3.55 (q, 2H, J=6.4 Hz), 5.24 (s, 2H), 5.51 (brs, 1H), 6.92 (s, 1H), 7.08–7.29 (m, 13H), and 7.59 (d, 1H, J=8.0 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 24.9, 25.5, 28.8, 33.3, 36.3, 39.9, 50.0, 110.0, 112.3, 119.1, 119.4, 122.2, 126.0, 126.3, 127.0, 127.8, 128.1, 128.9, 129.0, 129.1, 136.7, 136.9, 137.7, and 172.5; Anal. Calcd for $C_{28}H_{30}N_2SO$: C, 75.98; H, 6.83; N, 6.33. Found: C, 76.08; H, 6.90; N, 6.34.

5-Benzenesulfinyl-*N*-[2-(1-benzyl-1*H*-indol-3-yl)ethyl]-pentanamide (22). Using the standard procedure, a 0.9 g (2.0 mmol) sample of the above sulfide and 0.7 g (3.0 mmol) of $NaIO_4$ in 100 mL of a 1:1-methanol/water mixture gave 1.0 g (75%) of **22** as a yellow solid: mp 118–119°C; IR ($CHCl_3$) 3298, 1650, and 1544 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.56–1.78 (m, 4H), 2.06–2.11 (m, 2H), 2.74 (t, 2H, J=7.2 Hz), 2.94 (t, 2H, J=6.8 Hz), 3.55 (q, 2H, J=6.8 Hz), 5.26 (s, 2H), 5.72 (brs, 1H), 6.95 (s, 1H), 7.09–7.12 (m, 3H), 7.18 (td, 1H, J=7.2 and 1.2 Hz), 7.24–7.30 (m, 4H), 7.46–7.51 (m, 3H), and 7.56–7.60 (m, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 22.0, 24.7, 25.5, 36.2, 39.9, 50.0, 56.9, 110.0, 112.3, 119.1, 122.1, 124.1, 126.3, 127.0, 127.8, 128.1, 128.9, 129.4, 1311, 136.9, 137.7, 143.9, and 172.2; Anal. Calcd for $C_{28}H_{30}N_2SO_2$: C, 73.33; H, 6.59; N, 6.11. Found: C, 73.46; H, 6.62; N, 6.07.

1-[2-(1-Benzyl-1*H*-indol-3-yl)ethyl]-6-phenylsulfanyl-piperidin-2-one (24). To a solution containing 0.7 g (1.5 mmol) of **22** and 40 mL of acetonitrile was added 0.05 g (0.2 mmol) of ZnI_2, followed by 0.6 g (3.0 mmol) of *tert*-butyl-1-(methoxyvinyloxy)dimethylsilane. The solution was stirred at rt for 4 h and was quenched by the addition of 30 mL of a saturated $NaHCO_3$ solution. The mixture was extracted with CH_2Cl_2 and the combined organic layers were dried over $MgSO_4$. The solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give 0.36 g (54%) of **24** as a yellow oil: IR (neat) 3059, 1637, and 1544 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.54–1.63 (m, 2H), 2.04–2.30 (m, 3H), 3.05–3.09 (m, 1H), 3.45–3.53 (m, 1H), 3.57 (q, 1H, J=6.4 Hz), 4.16 (s, 1H), 4.24–4.30 (m, 1H), 5.14 (d, 1H, J=16.0 Hz), 5.24 (d, 1H, J=16.0 Hz), 6.87 (s, 1H), 6.96 (d, 1H, J=7.6 Hz), 7.06–7.27 (m, 12H), and 7.67 (d, 1H, J=8.0 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 16.8, 23.8, 28.8, 32.0, 47.0, 49.8, 70.1, 109.9, 112.9, 119.3, 119.4, 122.1, 126.0, 126.0, 126.7, 127.7, 128.0, 128.1, 128.8, 129.3, 133.6, 133.7, 136.9, 137.7, and 169.9; Anal. Calcd for $C_{28}H_{28}N_2SO$: C, 76.33; H, 6.41; N, 6.36. Found: C, 76.37; H, 6.54; N, 6.21.

12-Benzyl-2,3,6,7,12,12*b*-hexahydro-1*H*-indolo[2,3-*a*]-quinolizine-4-one (26). To a solution containing 0.24 g (0.6 mmol) of sulfide **24** and 20 mL of CH_2Cl_2 was added 0.2 mL (1 mmol) of $BF_3{\cdot}2AcOH$. The solution was stirred at rt for 5 h and was quenched by the addition of 2 mL of methanol. The mixture was poured into water, extracted with CH_2Cl_2 and the combined organic layers were dried over $MgSO_4$ and concentrated under reduced pressure. The residue was subjected to silica gel chromatography to give 0.17 g (95%) of **26** as a white solid: mp 189–190°C (lit.[51] mp 189–190°C); IR ($CHCl_3$) 3059, 1637, and 1451 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.48–1.58 (m, 1H), 1.63–1.82 (m, 2H), 2.32–2.41 (m, 2H), 2.53 (dd, 1H, J=17.6 and 6.0 Hz), 2.65–2.90 (m, 3H), 4.63–4.66 (m, 1H), 5.13–5.17 (m, 1H), 5.24 (d, 1H, J=17.6 Hz), 5.34 (d, 1H, J=17.6 Hz), 6.97 (d, 2H, J=6.8 Hz), 7.10–7.29 (m, 3H), 7.21–7.29 (m, 3H), and 7.53–7.55 (m, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 19.4, 21.6, 30.3, 32.1, 40.2, 47.9, 54.8, 109.9, 111.0, 118.5, 119.9, 122.2, 125.8, 126.6, 127.5, 128.9, 134.8, 137.3, 138.1, and 169.8; Anal. Calcd for $C_{22}H_{22}N_2O$: C, 79.97; H, 6.71; N, 8.48. Found: C, 79.87; H, 6.79; N, 8.40.

***N*-((2-Cyclohex-1-enyl)ethyl)-4-(phenylsulfanyl)butyramide.** Using the standard procedure, a 0.8 g (3.8 mmol)

sample of 4-phenylthiobutyric acid, 3.8 mL of a 2.0 M solution (7.6 mmol) of oxalyl chloride in CH_2Cl_2, and 1.0 mL (7.2 mmol) of 2-(1-cyclohexenyl)ethylamine in 30 mL of CH_2Cl_2 gave 0.8 g (68%) of the title compound as a white solid: mp 49–50°C; IR ($CHCl_3$) 3303, 1642, and 1550 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.50–1.63 (m, 4H), 1.90–1.99 (m, 6H), 2.10 (t, 2H, J=6.8 Hz), 2.31 (t, 2H, J=7.6 Hz), 2.95 (t, 2H, J=7.6 Hz), 3.30 (dd, 2H, J=12.4 and 6.8 Hz), 5.42–5.45 (m, 1H), 5.63 (brs, 1H), 7.17 (tt, 1H, J=9.2 and 1.6 Hz), and 7.25–7.34 (m, 4H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 22.5, 22.9, 25.0, 25.3, 27.9, 33.0, 35.0, 37.3, 36.7, 123.7, 126.1, 129.0, 129.3, 134.6, 139.1, and 172.1; Anal. Calcd for $C_{18}H_{25}NSO$: C, 71.25; H, 8.31; N, 4.62. Found: C, 71.13; H, 8.36; N, 4.54.

4-Benzenesulfinyl-*N*-((2-cyclohex-1-enyl)ethyl)butyramide (27). Using the standard procedure, a 0.3 g (1.0 mmol) sample of the above sulfide and 0.3 g (1.0 mmol) of $NaIO_4$ in 30 mL of a 1:1-methanol/water mixture gave 0.25 g (85%) of **27** as a white solid: mp 77–78°C; IR ($CHCl_3$) 3303, 1649, and 1550 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.49–1.54 (m, 2H), 1.56–1.62 (m, 3H), 1.88–2.13 (m, 7H), 2.29–2.38 (m, 2H), 2.79–2.86 (m, 1H), 2.88–2.96 (m, 1H), 3.28 (dd, 2H, J=12.8 and 7.0 Hz), 5.41 (brs, 1H), 6.37 (brs, 1H), 7.47–7.54 (m, 3H), and 7.59–7.62 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 18.8, 22.2, 22.7, 25.1, 27.9, 34.6, 37.3, 37.6, 55.9, 123.1, 123.9, 129.2, 131.0, 134.5, 143.3, and 171.3; Anal. Calcd for $C_{18}H_{25}NSO_2$: C, 67.68; H, 7.89; N, 4.39. Found: C, 67.67; H, 7.96; N, 4.46.

1-((2-Cyclohex-1-enyl)ethyl)-5-(phenylsulfanyl)pyrrolidin-2-one (28). To a solution containing 0.13 g (0.4 mmol) of sulfoxide **27**, 15 mL of acetonitrile, and 0.02 mg (0.04 mmol) of ZnI_2 was added 0.17 g (0.9 mmol) of *tert*-butyl-1-(methoxyvinyloxy)dimethylsilane. The reaction mixture was stirred for 12 h at rt and was quenched by the addition of 10 mL of a saturated $NaHCO_3$ solution. The mixture was extracted with CH_2Cl_2 and the combined organic layer was dried over $MgSO_4$. The solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give 0.1 g (76%) of **28** as a colorless oil: IR (neat) 2926, 1688, and 1247 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.43–1.54 (m, 4H), 1.61 (dt, 1H, J=17.2 and 9.2 Hz), 1.84–1.90 (m, 4H), 1.96–2.13 (m, 4H), 2.27–2.38 (m, 1H), 3.21 (tdd, 1 H, J=14.0, 7.6, and 0.8 Hz), 3.83 (dt, 1H, J=14.0 and 7.6 Hz), 4.82 (dd, 1H, J=7.6 and 2.0 Hz), 5.34 (s, 1H), 7.22–7.28 (m, 3H), and 7.34–7.36 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 22.4, 22.9, 25.4, 26.8, 28.0, 29.3, 35.7, 38.5, 67.5, 123.4, 129.0, 129.4, 130.8, 134.7, and 135.3; Anal. Calcd for $C_{18}H_{23}NSO$: C, 71.73; H, 7.70; N, 4.65. Found: C, 71.64; H, 7.64; N, 4.56.

1,5,7,8,9,10,10*a*,10*b*-Octahydro-2*H*-pyrrolo[2,1-*a*]isoquinolin-3-one (29). To a solution containing 0.1 g (0.33 mmol) of sulfide **28** and 15 mL of CH_2Cl_2 was added 0.1 mL (0.7 mmol) of $BF_3{\cdot}2AcOH$. The reaction mixture was stirred at rt for 4 h and was quenched by the addition of 1 mL of methanol. The solution was poured into water and extracted with CH_2Cl_2, and the combined organic layer was dried over $MgSO_4$. The solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give 0.04 g (54%) of **29** as a colorless oil: IR (neat) 2926, 1697, and 1418 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.40–1.72 (m, 5H), 1.82–1.91 (m, 2H), 1.99–2.28 (m, 4H), 2.37–2.43 (m, 2H), 2.60 (td, 1H, J=12.8 and 4.0 Hz), 3.07 (dt, 1H, J=9.6 and 7.6 Hz), 4.15 (ddd, 1H, J=12.8, 5.6, and 1.2 Hz), and 5.59–6.62 (m, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 21.9, 24.1, 26.3, 26.8, 31.5, 34.5, 41.6, 44.6, 63.9, 124.5, 136.4, and 173.7; Anal. Calcd for $C_{12}H_{17}NO$: C, 75.35; H, 8.96; N, 7.32. Found: C, 75.51; H, 9.01; N, 7.12.

***N*-((2-Cyclohex-1-enyl)ethyl)-5-(phenylsulfanyl)pentanamide.** Using the standard procedure, a 0.5 g (2.4 mmol) sample of 5-phenylthiopentanoic acid,[49] 2.4 mL of a 2.0 M solution (4.8 mmol) of oxalyl chloride in CH_2Cl_2, 1.0 mL (2.7 mmol) of 2-(1-cyclohexenyl)ethylamine, and 1.0 mL (7.2 mmol) of triethylamine in 25 mL of CH_2Cl_2 gave 0.74 g (97%) of the title compound as a colorless oil: IR (neat) 3298, 1644, and 1590 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.50–1.78 (m, 8H), 1.87–1.92 (m, 2H), 1.94–2.00 (m, 2H), 2.09 (t, 2H, J=6.8 Hz), 2.15 (t, 2H, J=7.4 Hz), 2.90 (t, 2H, J=6.8 Hz), 3.28 (dd, 2H, J=12.8 and 6.8 Hz), 5.40–5.44 (m, 1H), 5.90 (brs, 1H), 7.14 (tt, 1H, J=6.8 and 1.2 Hz), and 7.23–7.31 (m, 4H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 22.3, 22.8, 24.9, 25.2, 27.9, 28.6, 33.1, 36.0, 37.2, 37.6, 123.3, 125.7, 128.8, 128.9, 134.6, 136.6, and 172.4; Anal. Calcd for $C_{19}H_{27}NSO$: C, 71.88; H, 8.57; N, 4.41. Found: C, 71.77; H, 8.52; N, 4.29.

5-Benzenesulfinyl-*N*-((2-cyclohex-1-enyl)ethyl)pentanamide (30). Using the standard procedure, a 0.7 g (2.0 mmol) sample of the above sulfide and 0.7 g (4.0 mmol) of $NaIO_4$ in 30 mL of a 1:1-methanol/water mixture gave 0.64 g (82%) of **30** as a white solid: mp 44–45°C; IR ($CHCl_3$) 3296, 1637, and 1545 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.52–1.82 (m, 8H), 1.88–1.93 (m, 2H), 1.96–2.01 (m, 2H), 2.10 (t, 2H, J=6.8 Hz), 2.18 (dt, 2H, J=6.8 and 2.4 Hz), 2.81 (t, 2H, J=6.8 Hz), 3.29 (dd, 2H, J=12.4 and 6.8 Hz), 5.41–5.43 (m, 1H), 5.98 (brs, 1H), 7.49–7.55 (m, 3H), and 7.59–7.62 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 21.9, 22.4, 22.8, 24.8, 25.3, 27.9, 36.0, 37.3, 37.7, 56.9, 123.3, 123.9, 129.3, 131.1, 134.7, 143.7, and 172.1; Anal. Calcd for $C_{19}H_{27}NSO_2$: C, 68.43; H, 8.17; N, 4.20. Found: C, 68.29; H, 8.18; N, 4.13.

1-((2-Cyclohex-1-enyl)ethyl)-6-(phenylsulfanyl)piperidin-2-one (31). To a solution containing 0.6 g (2.0 mmol) of sulfoxide **30**, 25 mL of acetonitrile, and 0.06 g (0.19 mmol) of ZnI_2 was added 0.8 g (4.0 mmol) of *tert*-butyl-1-(methoxyvinyloxy)-dimethylsilane. The reaction mixture was stirred for 12 h at rt and was quenched by the addition of 15 mL of a saturated $NaHCO_3$ solution. The mixture was extracted with CH_2Cl_2 and the combined organic layer was dried over $MgSO_4$. The solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give 0.32 g (54%) of **31** as a colorless oil: IR (neat) 2926, 1657, and 1444 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.48–1.65 (m, 4H), 1.72–1.78 (m, 1H), 1.89–2.07 (m, 6H), 2.13–2.40 (m, 5H), 3.17 (dt, 1H, J=13.6 and 7.2 Hz), 4.16 (ddd, 1H, J=13.6, 7.2, and 6.2 Hz), 4.71–4.73 (m, 1H), 5.40 (brs, 1H), 7.32–7.37 (m, 3H), and 7.44–7.47 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 17.2, 22.5, 23.1, 25.5, 28.3, 29.6, 32.1, 36.0, 44.3, 69.4,

123.5, 128.4, 129.5, 134.1, 134.2, 135.1, and 169.8; Anal. Calcd for $C_{19}H_{25}NSO$: C, 72.34; H, 7.99; N, 4.44. Found: C, 72.10; H, 7.97; N, 4.39.

1,2,3,6,8,9,11,11*a*,11*b*-Decahydropyrido[2,1-*a*]isoquinolin-4-one (32). To a solution containing 0.2 g (0.7 mmol) of sulfide **31** and 25 mL of CH_2Cl_2 was added 0.2 mL (1.4 mmol) of $BF_3{\cdot}2AcOH$. The reaction mixture was stirred at rt for 4 h and was quenched by the addition of 1 mL of methanol. The solution was poured into water and extracted with CH_2Cl_2 and the combined organic layer was dried over $MgSO_4$. The solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give 0.7 g (52%) of **32** as a colorless oil: IR (neat) 2920, 1644, and 1444 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 0.84–0.91 (m, 1H), 1.05–1.14 (m, 1H), 1.24–1.28 (m, 2H), 1.38–1.47 (m, 1H), 1.75–1.87 (m, 2H), 1.92–2.02 (m, 3H), 2.06–2.12 (m, 1H), 2.15–2.17 (m, 2H), 2.28–2.45 (m, 3H), 2.87–2.94 (1H), 4.81 (ddd, 1H, J=12.4, 4.0, and 3.2 Hz), and 5.51–5.59 (m, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 19.1, 21.9, 25.3, 26.9, 27.4, 33.2, 34.6, 43.5, 62.4, 77.4, 112.8, 136.2, and 201.9; HRMS Calcd for $C_{13}H_{19}NO$: 205.1467. Found: 205.1463.

***N*-(3-Methylbut-3-enyl)-4-(phenylsulfanyl)butyramide.** Using the standard procedure, a 2.2 g (11 mmol) sample of 4-(phenylthio)butyric acid, 11.0 mL (22 mmol) of a 2.0 M solution of oxalyl chloride in CH_2Cl_2, 0.85 g (10.9 mmol) of 4-methyl-4-butene-1-amine,[52] and 1.5 mL (10.9 mmol) of Et_3N in 50 mL of CH_2Cl_2 gave 2.5 g (95%) of the title compound as a white solid: mp 40–42°C; IR ($CHCl_3$) 3298, 1644, and 1551; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.72 (s, 3H), 1.97 (quint, 2H, J=7.2 Hz), 2.19 (t, 2H, J=6.8 Hz), 2.31 (t, 2H, J=7.2 Hz), 2.96 (t, 2H, J=7.2 Hz), 3.36 (dd, 2H, J=12.4 and 5.6 Hz), 4.71–4.72 (m, 1H), 4.80–4.81 (m, 1H), 5.51 (brs, 1H), 7.18 (tt, 2H, J=7.2 and 1.6 Hz), and 7.26–7.34 (m, 4H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 22.1, 24.9, 33.1, 35.1, 37.5, 112.6, 126.2, 129.1, 129.3, 136.2, 142.7, and 172.1; Anal. Calcd for $C_{15}H_{21}NOS$: C, 68.40; H, 8.04; N, 5.32. Found: C, 68.24; H, 7.87; N, 5.06.

4-Benzenesulfinyl-*N*-(3-methylbut-3-enyl)butyramide (33). Using the standard procedure, a 1.0 g (3.8 mmol) sample of the above sulfide and 1.2 g (5.7 mmol) of $NaIO_4$ in 30 mL of a methanol/water mixture gave 0.9 g (86%) of **33** as a colorless oil: IR (neat) 3298, 1625, and 1544 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.73 (s, 3H), 1.98–2.15 (m, H), 2.35 (td, 2H, J=7.2 and 4.0 Hz), 2.79–2.99 (m, 4H), 3.37 (dd, 2H, J=12.0 and 5.4 Hz), 4.72–4.73 (m, 1H), 4.80–4.81 (m, 1H), 5.69 (brs, 1H), 7.50–7.55 (m, 3H), and 7.59–7.62 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 19.2, 22.2, 35.0, 37.2, 37.6, 56.0, 112.6, 124.1, 129.5, 131.2, 142.7, 143.7, and 171.5; HRMS Calcd for $C_{15}H_{21}NO_2S$: 279.1293. Found: 279.1293.

1-(3-Methylbut-3-enyl)-5-(phenylsulfanyl)pyrrolidin-2-one (34). To a solution containing 1.5 g (5.4 mmol) of sulfoxide **33**, 0.2 g (0.5 mmol) of ZnI_2, and 40 mL of acetonitrile was added 2.0 g (10.7 mmol) of *tert*-butyl-1-(methoxyvinyloxy)-dimethylsilane. The reaction mixture was allowed to stir at rt for 2 h and quenched with a saturated aqueous solution of $NaHCO_3$. The mixture was extracted with CH_2Cl_2 and the combined extracts were dried over $MgSO_4$. The solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give 1.0 g (71%) of **34** as a colorless oil: IR (neat) 3073, 1697, and 1411 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.67–1.73 (m, 1H), 1.76 (s, 3H), 2.05–2.13 (m, 1H), 2.16–2.27 (m, 3H), 2.38–2.48 (m, 1H), 3.35 (quint, H, J=6.8 Hz), 3.97 (t,1H, J=13.6 and 7.6 Hz), 4.70 (s, 1H), 4.77 (s, 1H), 4.91 (dd, 1H, J=7.6 and 2.0 Hz), 7.32–7.37 (m, 3H), and 7.42–7.45 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 22.3, 26.9, 29.4, 35.5, 38.4, 67.5, 112.4, 129.2, 129.5, 130.8, 135.4, 142.8, and 174.6; Anal. Calcd for $C_{15}H_{19}NOS$: C, 68.93; H, 7.33; N, 5.36. Found: C, 68.67; H, 7.30; N, 5.20.

7-Hydroxy-7-methylhexahydroindolizin-3-one (35). To a solution containing 0.1 g (0.4 mmol) of sulfide **34** and 10 mL of CH_2Cl_2 at −40°C was added 0.08 g (0.42 mol) of DMTSF. The reaction mixture was allowed to warm to rt, stirred for 5 h, and quenched by the addition of water. The mixture was extracted with CH_2Cl_2 and the combined extracts were dried over $MgSO_4$. The solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give 0.05 g (74%) of **35** as a colorless oil: IR (neat) 3502, 1695, and 1442 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.20–1.36 (m, 2H), 1.40 (d, 3H, J=21.6 Hz), 1.45–1.55 (m, 1H), 7.87–1.92 (m, 1H), 2.07–2.14 (m, 1H), 2.21–2.29 (m, 1H), 2.38–2.43 (m, 2H), 2.97 (td, 1H, J=12.8 and 3.2 Hz), 3.47 (brs, 1H), 3.75–3.83 (m, 1H), and 4.04 (ddd, 1H, J=13.6, 3.6, and 0.8 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 24.8, 27.5, 30.3, 34.9, 43.8, 52.6, 92.0, 93.7, and 173.7; HRMS Calcd for $C_9H_{15}NO_2$: 169.0103. Found: 169.0102.

3-Bromo-3-butene amine. To a solution containing 10.0 g (66 mmol) of 3-bromo-3-buten-1-ol and 50 mL of ether at 0°C was added 10 mL (73 mmol) of triethylamine followed by 5.6 mL (73 mmol) of methanesulfonyl chloride. The reaction mixture was allowed to stir for 2 h at 0°C and was quenched by the addition of water. The mixture was extracted with ether and the combined organic layer was washed with brine and dried over $MgSO_4$. The solvent was removed under reduced pressure and the residue was taken up in 50 mL of DMF. To this solution was added 8.5 g (130 mmol) of sodium azide and the mixture was heated at 60°C for 3.5 h. After cooling to rt, 100 mL of water was added and the mixture was extracted with ether. The combined organic layer was dried over $MgSO_4$ and filtered through a pad of Celite. To this ethereal solution of 3-bromo-3-butenylazide was added 13.1 g (50 mmol) of triphenyl phosphine and the reaction mixture was stirred at rt for 3 h. To this solution was added 10 mL of water and the mixture was allowed to stir for 12 h at rt. The organic layer was separated, dried over $MgSO_4$, concentrated to one half its previous volume, and filtered to remove triphenyl phosphine oxide. The filtrate was distilled (20 mm) to give 6.3 g (63%) of the title compound as a clear oil: IR (neat) 3298, 1577, and 1324 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.16 (brs, 2H), 2.55 (td, 2H, J=6.4 and 1.8 Hz), 2.92 (t, 2H, J=6.4 Hz), 5.51 (d, 1H, J=1.6 Hz), and 5.66–5.67 (m, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 40.0, 45.5, 118.8, and 132.1; HRMS Calcd for C_4H_8NBr: 148.9841. Found: 148.9840.

***N*-(3-Bromobut-3-enyl)-4-(phenylsulfanyl)butyramide.** Using the standard procedure, a 2.2 g (11 mmol) sample of 4-phenylthiobutyric acid, 11 mL of a 2.0 M solution (22 mmol) of oxalyl chloride in CH_2Cl_2, 1.5 g (10 mmol) of the above amine, and 1.5 mL (11 mmol) of triethylamine in 100 mL of CH_2Cl_2 gave 3.1 g (95%) of the title compound as a colorless oil: IR (neat) 3303, 1642, and 1550 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.97 (quint, 2H, J=7.0 Hz), 2.33 (t, 2H, J=7.0 Hz), 2.61 (t, 2H, J=6.2 Hz), 2.97 (t, 2H, J=7.0 Hz), 3.46 (dd, 2H, J=12.4 and 6.2 Hz), 5.47 (d, 1H, J=1.6 Hz), 5.59 (brs, 1H), 5.60–5.61 (m, 1H), 7.18 (tt, 1H, J=7.6 and 1.2 Hz), and 7.26–7.35 (m, 4H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 24.9, 33.2, 34.9, 37.7, 41.2, 119.4, 126.3, 129.2, 129.5, 131.2, 136.2, and 172.3; Anal. Calcd for $C_{14}H_{18}NSOBr$: C, 51.22; H, 5.53; N, 4.27. Found: C, 51.32; H, 5.61; N, 4.29.

4-Benzenesulfinyl-*N*-(3-bromobut-3-enyl)butyramide (36). Using the standard procedure, a 2.4 g (7.0 mmol) sample of the above sulfide and 2.4 g (11 mmol) of $NaIO_4$ in 80 mL of a 1:1-methanol/water mixture gave 2.2 g (89%) of **36** as a colorless oil: IR (neat) 3298, 1650, and 1544 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.96–2.07 (m, 1H), 2.07–2.17 (m, 1H), 2.38 (t, 2H, J=7.2 Hz), 2.63 (t, 2H, J=6.6 Hz), 2.80–2.95 (m, 2H), 3.46 (dd, 2H, J=12.8 and 6.6 Hz), 5.46–5.48 (m, 1H), 5.62–5.63 (m, 1H), 6.00 (brs, 1H), 7.49–7.56 (m, 3H), and 7.60–7.63 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 19.2, 34.1, 37.7, 41.2, 55.9, 119.3, 124.1, 129.5, 131.2, 131.3, 143.6, and 171.8; Anal. Calcd for $C_{14}H_{18}NSO_2Br$: C, 48.84; H, 5.27; N, 4.07. Found: C, 48.78; H, 5.36; N, 3.93.

1-(3-Bromobut-3-enyl)-5-(phenylsulfanyl)pyrrolidin-2-one (37). To a solution containing 0.2 g (0.6 mmol) of sulfoxide **36**, 15 mL of acetonitrile, and 0.02 g (0.06 mmol) of ZnI_2 was added 0.2 g (1.2 mmol) of *tert*-butyl-1-(methoxyvinyloxy)-dimethylsilane.[73] The reaction mixture was stirred for 2 h at rt and was quenched by the addition of 10 mL of a saturated $NaHCO_3$ solution. The mixture was extracted with CH_2Cl_2 and the combined organic layer was dried over $MgSO_4$. The solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give 0.15 g (80%) of **37** as a white solid: mp 93–94°C; IR ($CHCl_3$) 3059, 1703, and 1404 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.69 (dt, 1H, J=17.2 and 9.4 Hz), 2.08 (ddd, 1H, J=17.2, 10.0, and 2.8 Hz), 2.17–2.23 (m, 1H), 2.39–2.49 (m, 1H), 2.59–2.66 (m, 1H), 2.73–2.80 (m, 1H), 3.55 (dt, 1H, J=14.0 and 6.8 Hz), 3.91 (dt, 1H, J=14.0 and 6.8 Hz), 4.94 (dd, 1H, J=8.0 and 1.2 Hz), 4.46–4.46 (m, 1H), 5.63–5.64 (m, 1H), 7.33–7.37 (m, 3H), and 7.43–7.45 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 26.9, 29.1, 39.0, 39.4, 68.2, 119.0, 129.1, 129.4, 130.5, 130.7, 135.4, and 174.6; Anal. Calcd for $C_{14}H_{16}NSOBr$: C, 51.54; H, 4.94; N, 4.29. Found: C, 51.47; H, 4.93; N, 4.23.

Hexahydroindolizin-3,7-dione (39). To a solution containing 0.1 g (0.3 mmol) of sulfide **37** and 15 mL of CH_2Cl_2 was added 0.1 mL (0.9 mmol) of $BF_3{\cdot}2AcOH$. The reaction mixture was allowed to stir at rt for 48 h and was quenched by the addition of 1 mL of methanol. The solution was poured into water and extracted with CH_2Cl_2. The combined organic layer was washed with a 10% KOH solution, dried over $MgSO_4$, and the solvent was removed under reduced pressure. The mixture was taken up in 5 mL of 98% formic acid and 0.07 g (0.2 mmol) of $Hg(OAc)_2$ was added. The reaction mixture was allowed to stir at rt for 12 h and was poured into brine, extracted with CH_2Cl_2 and the combined organic layer was dried over $MgSO_4$. The solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give **39** (64% overall) as a white solid: mp: 54–55°C (lit.[41] mp 54–55°C); IR ($CHCl_3$) 1710, 1620, and 1420 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.72–1.81 (m, 1H), 2.30 (dd, 1H, J=14.4 and 12.0 Hz), 2.35–2.53 (m, 5H), 2.62 (ddd, 1H, J=14.4, 10.0, and 1.6 Hz), 2.97–3.04 (m, 1H), 3.81–3.88 (m, 1H), and 4.43 (ddd, 1H, J=13.2, 6.8, and 3.2 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 25.2, 29.9, 38.2, 40.1, 48.8, 56.6, 173.9, and 206.5; Anal. Calcd for $C_8H_{11}NO_2$: C, 62.71; H, 7.24; N, 9.15. Found: C, 62.59; H, 7.08; N, 9.26.

***N*-(3-Bromobut-3-enyl)-5-(phenylsulfanyl)pentanamide.** Using the standard procedure, a 1.0 g (5.0 mmol) sample of 5-(thiophenyl)pentanoic acid,[49] 5.0 mL of a 2.0 M solution (10 mmol) of oxalyl chloride in CH_2Cl_2, 0.8 g (5.2 mmol) of 3-bromo-3-butene amine, and 0.7 mL (5.0 mmol) of Et_3N in 50 mL of CH_2Cl_2 gave 1.6 g (99%) of the title compound as a white solid: mp 41–42°C; IR ($CHCl_3$) 3290, 1647, and 1432 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.62–1.70 (m, 2H), 1.73–1.81 (m, 2H); 2.17 (t, 2H, J=7.6 Hz), 2.61 (td, 2H, J=6.4 and 0.8 Hz), 2.93 (t, 2H, J=7.6 Hz), 3.45 (q, 2H, J=6.4 Hz), 5.48 (d, 1H, J=2.0 Hz), 5.55 (brs, 1H), 5.61–5.62 (m, 1H), 7.17 (tt, 1H, J=7.2 and 1.6 Hz), and 7.26–7.33 (m, 4H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 24.9, 28.8, 33.4, 36.3, 37.6, 41.2, 119.3, 126.1, 129.1, 129.2, 131.2, 136.7, and 172.8; Anal. Calcd for $C_{15}H_{20}NSOBr$: C, 52.63; H, 5.89; N, 4.09. Found: C, 52.55; H, 5.83; N, 4.19.

***N*-(3-Bromobut-3-enyl)-5-(benzenesulfinyl)pentanamide (40).** Using the standard procedure, a 1.5 g (4.2 mmol) sample of the above sulfide and 1.3 g (6.3 mmol) of $NaIO_4$ in 60 mL of a 1:1-methanol/water mixture gave 1.3 g (82%) of **40** as a colorless oil: IR (neat) 3291, 1647, and 1539 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.61–1.85 (m, 6H), 2.19 (td, 2H, J=7.6 and 2.8 Hz), 2.62 (t, 2H, J=6.4 Hz), 2.78–2.82 (m, 2H), 3.46 (q, 2H, J=6.4 Hz), 5.49–5.50 (m, 1H), 5.63–5.64 (m, 1H), 5.68 (brs, 1H), 7.48–7.55 (m, 3H), and 7.59–7.62 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 21.9, 24.7, 35.9, 37.7, 41.1, 56.9, 119.1, 124.0, 129.4, 131.2, 143.7, and 172.5; Anal. Calcd for $C_{15}H_{20}NSO_2Br$: C, 50.28; H, 5.63; N, 3.91. Found: C, 50.07; H, 5.64; N, 3.80.

***N*-(3-Bromobut-3-enyl)-6-(phenylsulfanyl)piperidin-2-one (41).** To a solution containing 0.8 g (2.1 mmol) of sulfoxide **40**, 35 mL of acetonitrile, and 0.07 g (0.2 mmol) of ZnI_2 was added 0.9 g (4.6 mmol) of *tert*-butyl-1-(methoxyvinyloxy)-dimethylsilane. The reaction mixture was stirred for 2 h at rt and was quenched by the addition of 10 mL of a saturated $NaHCO_3$ solution. The mixture was extracted with CH_2Cl_2 and the combined organic layer was dried over $MgSO_4$. The solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give 0.5 g (72%) of **41** as a colorless oil: IR (neat) 2955, 1647, and 1163 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.72–1.81 (m, 1H), 1.90–2.05 (m, 2H), 2.24–2.37 (m, 2H), 2.60–2.66 (m, 2H), 2.82–2.89 (m, 1H), 3.42–3.50 (m, 1H), 4.04

(ddd, 1H, J=13.6, 6.7, and 4.4 Hz), 4.83–4.85 (m, 1H), 5.44 (d, 1H, J=1.6 Hz), 5.60–5.61 (m, 1H), 7.28–7.37 (m, 3H), and 7.49–7.52 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 17.0, 29.3, 32.0, 40.1, 45.3, 70.4, 119.3, 126.6, 128.6, 129.5, 131.6, 134.4, and 170.1; Anal. Calcd for $C_{15}H_{18}NSOBr$: C, 52.95; H, 5.33; N, 4.12. Found: C, 52.98; H, 5.41; N, 4.09.

Octahydroquinolizin-4,8-dione (43). To a solution containing 0.08 g (0.2 mmol) of sulfide **41** and 10 mL of CH_2Cl_2 was added 0.06 mL (0.5 mmol) of $BF_3{\cdot}2AcOH$. The reaction mixture was allowed to stir at rt for 24 h and was quenched by the addition of 1 mL of methanol. The solution was poured into water and extracted with CH_2Cl_2. The combined organic layer was washed with a 10% KOH solution, dried over $MgSO_4$, and the solvent was removed under reduced pressure. The mixture was taken up in 5 mL of 98% formic acid and 0.1 g (0.3 mmol) of $Hg(OAc)_2$ was added. The reaction mixture was allowed to stir at rt for 12 h, poured into brine and extracted with CH_2Cl_2. The combined organic layer was dried over $MgSO_4$ and the solvent was removed under reduced pressure. The residue was subjected to silica gel chromatography to give 0.02 g (58%) of the known octahydroquinolizin-4,8-dione **43**[41] as a colorless oil: IR (neat) 1725, 1645, and 1450 cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 1.58–1.66 (m, 1H), 1.76–1.85 (m, 1H), 1.87–1.97 (m, 1H), 2.07–2.15 (m, 1H), 2.42–2.50 (m, 6H), 2.88–2.95 (m, 1H), 3.71 (dq, 1H, J=9.2 and 6.0 Hz), and 4.91 (ddd, 1H, J=4.0, 6.0, and 13.2 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 19.0, 29.8, 32.9, 40.8, 41.1, 48.3, 55.1, 169.7, and 207.1; Anal. Calcd for $C_9H_{13}NO_2$: C, 64.63; H, 7.84; N, 8.38. Found: C, 64.49; H, 7.58; N, 8.17.

***N*-(2-Benzo[1,3]dioxol-5-yl-ethyl)-2-((2-phenylsulfanyl)-ethyl)benzamide.** Using the standard procedure, a 1.7 g (6.6 mmol) sample of 2-[(ethylthio)ethyl]benzoic acid,[53] 5.5 mL (16 mmol) of a 2.0 M solution of oxalyl chloride in CH_2Cl_2, 1.6 g (10 mmol) of 2-benzo-[1,3]dioxol-5-ylethylamine,[54] and 1.4 mL (10 mmol) of triethylamine in 50 mL of CH_2Cl_2 gave 2.0 g (75%) of the title compound as a white solid: mp 90–91°C; IR ($CHCl_3$) 3298, 1644, and 1251 cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 2.79 (t, 2H, J=6.8 Hz), 3.04–3.08 (m, 2H), 3.20–3.24 (m, 2H), 3.60 (q, 2H, J=6.8 Hz), 5.82 (brs, 1H), 5.92 (s, 2H), 6.64 (dd, 1H, J=7.6 and 1.6 Hz), 6.69 (d, 1H, J=1.6 Hz), 6.73 (d, 1H, J=7.6 Hz), 7.14–7.19 (m, 1H), 7.21–7.29 (m, 5H), and 7.31–7.35 (m, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 33.5, 34.9, 35.6, 41.2, 101.1, 108.6, 109.2, 121.9, 125.9, 126.8, 127.0, 129.0, 129.1, 130.2, 130.9, 132.6, 131.2, 136.8, 138.5, 146.5, 148.1, and 169.9; Anal. Calcd for $C_{24}H_{23}NSO_3$: C, 71.09; H, 5.72; N, 3.45. Found: C, 71.19; H, 5.76; N, 3.45.

2-((2-Benzenesulfinyl)ethyl)-*N*-((2-benzo[1,3]dioxol-5-yl)-ethyl)benzamide (44). Using the standard procedure, a 1.7 g (4.0 mmol) sample of the above sulfide and 1.3 g (6.0 mmol) of $NaIO_4$ in 80 mL of a 1:1 methanol/water mixture gave 1.7 g (94%) of **44** as a white solid: mp 109–110°C; IR ($CHCl_3$) 3278, 1637, and 1477 cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 2.81 (td, 2H, J=7.2 and 2.4 Hz), 2.97–3.03 (m, 1H), 3.05–3.12 (m, 1H), 3.16–3.20 (m, 1H), 3.22–3.30 (m, 1H), 3.61 (qd, 2H, J=6.8 and 1.6 Hz), 5.94 (s, 2H), 6.01 (brs, 1H), 6.66 (dd, 1H, J=8.0 and 1.6 Hz), 6.71 (d, 1H, J=1.6 Hz), 6.75 (d, 1H, J=8.0 Hz), 7.20–7.28 (m, 3H), 7.34 (td, 1H, J=8.0 and 2.0 Hz), 7.44–7.53 (m, 3H), and 7.63 (dd, 2H, J=8.0 and 2.0 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 26.9, 35.5, 41.3, 58.6, 101.2, 108.6, 109.2, 121.9, 124.3, 127.1, 127.2, 129.4, 130.5, 130.9, 131.0, 132.6, 136.8, 137.4, 143.8, 146.5, 148.1, and 169.7; Anal. Calcd for $C_{24}H_{23}NSO_4$: C, 68.39; H, 5.50; N, 3.32. Found: C, 68.27; H, 5.56; N, 3.19.

2-((2-Benzo[1,3]dioxol-5-yl)ethyl)-3-phenylsulfanyl-3,4-dihydro-2*H*-isoquinolin-1-one (45). To a solution containing 0.1 g (0.2 mmol) of **44** in 15 mL of CH_2Cl_2 at 0°C was added 0.04 mL (0.3 mmol) of triethylamine followed by 0.05 mL (0.3 mmol) of TMSOTf. After stirring at 0°C for 30 min, the reaction mixture was quenched by the addition of water and extracted with CH_2Cl_2. The combined organic layers were dried over $MgSO_4$. The solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give 0.06 g (64%) of **45** as a white solid: mp 92–93°C; IR ($CHCl_3$) 3073, 1730, and 1484 cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 2.83 (t, 2H, J=7.6 Hz), 3.16 (dd, 1H, J=16.0 and 6.4 Hz), 3.39 (dd, 1H, J=16.0 and 4.2 Hz), 3.61 (td, 2H, J=7.6 and 2.8 Hz), 5.77 (dd, 1H, J=6.4 and 4.2 Hz), 5.91 (s, 2H), 6.68 (dd, 1H, J=7.6 and 1.6 Hz), 6.73 (d, 1H, J=7.6 Hz), 6.75 (d, 1H, J=1.6 Hz), 7.17 (d, 1H, J=7.6 Hz), 7.31–7.34 (m, 4H), 7.39 (td, 1H, J=7.6 and 1.6 Hz), 7.50–7.52 (m, 2H), and 8.11 (dd, 1H, J=7.6 and 1.6 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 34.4, 37.2, 48.6, 83.7, 100.9, 108.2, 109.6, 121.8, 127.6, 127.7, 127.8, 128.0, 128.2, 129.3, 130.9, 132.8, 133.0, 134.2, 135.0, 145.8, 147.5, and 151.4; Anal. Calcd for $C_{24}H_{21}NSO_3$: C, 71.40; H, 5.25; N, 3.47. Found: C, 71.25; H, 5.18; N, 3.43.

2-(2-Benzo[1,3]dioxol-5-yl)ethyl-2*H*-isoquinolin-1-one (46). To a solution containing 0.2 g (0.4 mmol) of **44** and 15 mL of acetonitrile was added 0.03 g (0.08 mmol) of ZnI_2, followed by 0.2 g (1.0 mmol) of *tert*-butyl-1-(methoxyvinyl-oxy)dimethylsilane. The solution was stirred at rt for 15 h and was quenched by the addition of 10 mL of a saturated $NaHCO_3$ solution. The mixture was extracted with CH_2Cl_2, and the combined organic layers were dried over $MgSO_4$. The solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give 0.01 g (85%) of **46** as a white solid: mp 90–91°C (lit.[55] mp 89–91°C); IR ($CHCl_3$) 3030, 1630, and 1435 cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 3.00 (t, 2H, J=7.2 Hz), 4.15 (t, 2H, J=7.2 Hz), 5.92 (s, 2H), 6.38 (d, 1H, J=7.2 Hz), 6.61 (dd, 1H, J=7.6 and 1.2 Hz), 6.70–6.71 (m, 2H), 6.80 (d, 1H, J=7.6 Hz), 7.46–7.50 (m, 2H), 7.62 (dd, 1H, J=7.6 and 1.2 Hz), and 8.45 (td, 1H, J=7.6 and 1.2 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 35.1, 51.8, 101.0, 105.8, 108.5, 109.4, 122.1, 126.0, 126.3, 126.5, 126.9, 127.9, 132.1, 132.2, 137.2, 146.4, 147.9, 162.2; Anal. Calcd for $C_{18}H_{15}NO_3$: C, 73.69; H, 5.16; N, 4.78. Found: C, 73.41; H, 5.08; N, 4.55.

5,6,13,13*a*-Tetrahydro[1,3]dioxolo[4,5-*g*]isoquino[3,2-*a*]-isoquinolin-8-one (47). A solution containing 0.04 g (0.1 mmol) of sulfide **45** and 10 mL of concentrated HCl was stirred at rt for 48 h. The reaction mixture was poured over ice and extracted with $CHCl_3$. The combined organic layer was washed with a saturated solution of $NaHCO_3$ and

dried over $MgSO_4$. The solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give 0.02 g (55%) of **47** as a white solid: mp 175–177°C (lit.[56] mp 175–177°C); IR ($CHCl_3$) 3052, 1650, and 1451 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 2.83–2.89 (m, 1H), 2.90–3.00 (m, 3H), 3.10–3.15 (m, 1H), 4.70–5.10 (m, 2H), 5.93 (s, 2H), 6.76 (s, 1H), 6.78 (s, 1H), 7.25–7.65 (m, 3H), and 8.07 (d, 1H, J=8.0 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 29.7, 33.5, 42.0, 49.4, 100.9, 107.3, 107.5, 117.3, 124.6, 126.4, 126.5, 126.8, 127.1, 127.9, 128.7, 126.0, 147.0, and 162.2; Anal. Calcd for $C_{18}H_{15}NO_3$: C, 73.69; H, 5.16; N, 4.78. Found: C, 73.52; H, 5.13; N, 4.65.

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