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# Gold(I)-Catalyzed Synthesis of 1,5-Benzodiazepines Directly from *o*-Phenylenediamines and Alkynes

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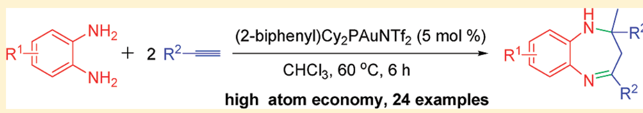
Supporting Information

**ABSTRACT:** A unique gold(I)-catalyzed highly atom-economic synthesis of 1,5-benzodiazepines directly from *o*-phenylenediamines and alkynes has been achieved for the first time.




Benzodiazepines have recently received much attention as an important class of *N*-heterocyclic compounds exhibiting a broad spectrum of biological and pharmacological activities, such as anti-inflammatory, anticonvulsant, antianxiety, sedative, antidepressive, and hypnotic activities.[1] Several representative medicinal candidates containing a 1,5-benzodiazepine scaffold are exemplified in Figure 1 including compounds **I** and **II**,[2] two drugs for the treatment of schizophrenia, and compound **III**,[3] an inhibitor of HIV-1 capsid assembly. In addition, 1,5-benzodiazepines are also useful intermediates for the synthesis of some fused ring compounds.[4]

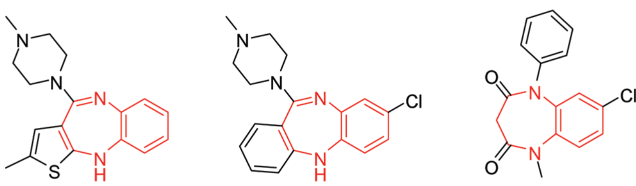



**Figure 1.** Representative compounds containing a 1,5-benzodiazepine scaffold.

The traditional strategies for the synthesis of 1,5-benzodiazepines basically rely on the condensation reactions of *o*-phenylenediamines with *α*,*β*-unsaturated carbonyl compounds,[5] *β*-haloketones,[6] or ketones[5a,7] (Scheme 1, paths a−c). These reactions can offer effective methods for the synthesis of 1,5-benzodiazepines. However, they inevitably suffer from unsatisfactory atom economy. Therefore, from the sustainable and atom-economic synthesis point of view, it is still highly desirable to develop alternative approaches for the synthesis of 1,5-benzodiazepines with higher atom economy.

Alkynes are ubiquitous and easily available structures in organic synthesis, serving as important synthetic precursors and subunits for various useful organic compounds.[8] In the past decade, gold[9] has emerged as a powerful catalyst for the electrophilic activation of alkynes toward a variety of nucleophiles under homogeneous conditions, thus enabling the construction of carbon−carbon or carbon−heteroatom bonds (e.g., C−N bonds[10,11]) with high selectivity and efficiency. In light of the easy availability of alkynes and the extraordinary ability of gold to activate alkynes, we envisioned that alkynes would be alternative precursors for the synthesis of 1,5-benzodiazepines. As part of our ongoing project devoted toward the development of efficient and highly atom-economic synthesis of heterocycles via gold-catalyzed reactions,[12,13] we herein report a unique gold(I)-catalyzed synthesis of 1,5-benzodiazepines directly from *o*-phenylenediamines and alkynes. To the best of our knowledge, this is the first example of an alkyne-based and a highly atom-economic synthesis of 1,5-benzodiazepines (Scheme 1, path d).

Initially, *o*-phenylenediamine **1a** and phenylacetylene **2a** were chosen as the model substrates to optimize suitable conditions for this reaction (Table 1). When the reaction was tested with $Ph_3PAuNTf_2$ (2.5 mol % based on **1a**) in $CH_2Cl_2$ at room temperature for 24 h, the desired 1,5-benzodiazepine **3a** was indeed isolated in 41% yield, and the yield of **3a** was further increased to 46% at 40 °C for 6 h (entry 1, Table 1). When $IMesAuNTf_2$[14] (IMes = 1,3-bis(mesityl)imidazol-2-ylidene) was used as a catalyst in $CH_2Cl_2$ or $CHCl_3$ at 40 °C for 6 h, **3a** was obtained in 49 and 59% yield, respectively (entries 2 and 3, Table 1). Employing the same catalyst, this yield could be further improved up to 90% by increasing the temperature and using a higher catalyst loading (5 mol %, entry 3, Table 1). It was found that (2-biphenyl)$Cy_2PAuNTf_2$[15] was the most effective catalyst for the reaction, in which case **3a** could be produced in 93% yield in $CHCl_3$ at 60 °C for 6 h (entry 4, Table 1). A combination of (2-biphenyl)$Cy_2PAuCl$ with $AgNTf_2$ gave almost the same result (entry 5, Table 1). However, the use of (2-biphenyl)$Cy_2PAuCl$ or $AgNTf_2$ alone led to a very poor result (entries 6 and 7, Table 1). Counteranion and solvent screening experiments showed that both parameters had a significant effect on the outcome of the

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**Scheme 1. Strategies for the Synthesis of 1,5-Benzodiazepines**

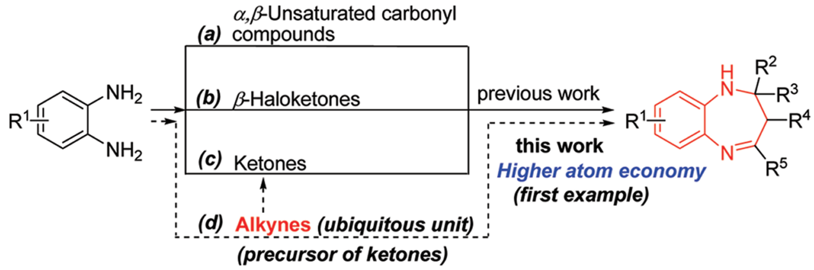
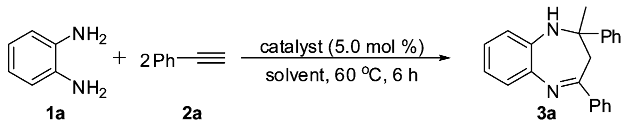



**Table 1. Optimization of Reaction Conditions**[a]




| entry | catalyst | solvent | yield (%)[b] |
|---|---|---|---|
| 1 | $PPh_3AuNTf_2$ | $CH_2Cl_2$ | 41,[c,d] 46[c,e] |
| 2 | $IMesAuNTf_2$ | $CH_2Cl_2$ | 49[c,e] |
| 3 | $IMesAuNTf_2$ | $CHCl_3$ | 59,[c,e] 73,[c] 90 |
| **4** | **(2-biphenyl)$Cy_2PAuNTf_2$** | **$CHCl_3$** | **93**, 67[h] |
| 5 | (2-biphenyl)$Cy_2PAuCl/AgNTf_2$ | $CHCl_3$ | 92 |
| 6 | (2-biphenyl)$Cy_2PAuCl$ | $CHCl_3$ | trace |
| 7 | $AgNTf_2$ | $CHCl_3$ | –[i] |
| 8 | (2-biphenyl)$Cy_2PAuCl/AgOTf$ | $CHCl_3$ | 89 |
| 9 | (2-biphenyl)$Cy_2PAuCl/AgSbF_6$ | $CHCl_3$ | 86 |
| 10 | (2-biphenyl)$Cy_2PAuCl/AgNO_2$ | $CHCl_3$ | trace |
| 11 | (2-biphenyl)$Cy_2PAuCl/AgCN$ | $CHCl_3$ | trace |
| 12 | (2-biphenyl)$Cy_2PAuCl/AgF$ | $CHCl_3$ | trace |
| 13 | AuCl | $CHCl_3$ | –[i] |
| 14 | IMesAuCl | $CHCl_3$ | –[i] |
| 15 | $PPh_3AuCl$ | $CHCl_3$ | –[i] |
| 16 | $AuCl_3$ | $CHCl_3$ | –[i] |
| 17 | $AuCl/AgNTf_2$ | $CHCl_3$ | trace |
| 18 | $AuCl_3/3AgNTf_2$ | $CHCl_3$ | –[i] |
| 19 | $NaAuCl_4·2H_2O$ | $CHCl_3$ | –[i] |
| 20 | $HAuCl_4·4H_2O$ | $CHCl_3$ | –[i] |
| 21 | Lewis acids[f] | $CHCl_3$ | –[i] |
| 22 | Brϕnsted acids[g] | $CHCl_3$ | –[i] |
| 23 | none | $CHCl_3$ | –[i] |

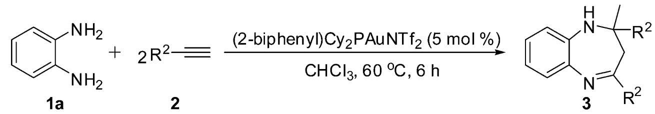
[a]All the reactions were carried out with **1a** (0.2 mmol) and **2a** (0.5 mmol) in the presence of catalyst (5.0 mol % based on **1a**) in solvent (2.0 mL) at 60 °C for 6 h unless otherwise noted. [b]Isolated yields. [c]2.5 mol % of catalyst was used. [d]The reaction was carried out at room temperature for 24 h. [e]The reaction temperature was 40 °C. [f]Lewis acids, such as CuI, $PdCl_2$, $BiCl_3$, $ZnCl_2$, $FeCl_3$, and $Cu(OTf)_2$. [g]Brϕnsted acids, such as HOTf, $HNTf_2$, and aqueous HCl (37 wt %). [h]0.4 mmol of **2a** was used. [i]No desired product was detected.

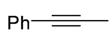
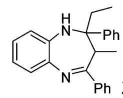
reaction (entries 4, 5, 8–12, Table 1; Table S2 in the Supporting Information). The activity of other gold catalysts on the reaction was examined, and all failed to give the desired product (entries 13–20, Table 1). Control experiments showed that no reaction occurred in the absence of a gold catalyst (entry 23, Table 1). Moreover, treatments of the model substrates with some conventional Lewis or Brϕnsted acids, such as CuI, $PdCl_2$, $BiCl_3$, $ZnCl_2$, $FeCl_3$, $Cu(OTf)_2$, HOTf, $HNTf_2$, or HCl were done, and all failed to give the desired product (entries 21 and 22, Table 1), indicating that (2-biphenyl)$Cy_2PAuNTf_2$ had a unique ability to achieve a high reactivity for the reaction.

To investigate the scope of the reaction, we first examined the cycloaddition of **1a** with various terminal alkynes **2** under the optimal reaction conditions (Table 2). In the participation of aromatic terminal alkynes, the reaction proceeded smoothly to furnish 1,5-benzodiazepines **3** in moderate to excellent yields (51–97%, entries 1–11, Table 2). The reaction of **1a** with aliphatic terminal alkynes also occurred, albeit it generally required longer reaction times and gave lower yields of desired products (entries 13 and 14, Table 2). Surprisingly, when cyclopropyl acetylene **2l** was used, the reaction underwent smoothly to furnish target product **3l** in an unexpectedly high yield of 96% (entry 12, Table 2). Among the alkynes bearing *para*-substituted aryl groups, it was found that those substituted with electron-withdrawing groups gave better yields of **3** than those substituted with electron-donating ones (entries 6, 9, 10 vs 2–5, Table 2). Note that the *ortho*- or *meta*-substituted phenylalkynes generally gave slightly lower yields of target products compared with the *para*-substituted phenylalkynes (entries 7, 8 vs 2–6, 9, and 10, Table 2). Besides, a heterocycle-substituted terminal alkyne **2k** could be well tolerated under the reaction conditions, and the corresponding product **3k** was obtained in 97% yield (entry 11, Table 2). An attempt to employ internal alkyne **2o** as a substrate failed to give any desired product (entry 15, Table 2).

Then, further investigations were undertaken to examine the capability of the catalysis system to catalyze the tandem amination/cyclization reaction of various *o*-phenylenediamines with alkynes under the optimized reaction conditions. As seen from Table 3, both mono- and disubstituted *o*-phenylenediamines could react with alkynes to afford the corresponding 1,5-benzodiazepines in moderate to excellent yields (66–98%, entries 1–10, Table 3). It was found that electron-rich *o*-phenylenediamines **1** reacted with alkynes more smoothly to furnish the corresponding products **3** in higher yields (91–98%, entries 1–4 and 7, Table 3) than those electron-deficient *o*-phenylenediamines (66–80%, entries 5, 6, and 8–10, Table 3). Unfortunately, two regioisomeric products were obtained when an unsymmetrical *o*-phenylenediamine was employed as a substrate (entries 7–10, Table 3). It seemed that the electronic situation of *o*-phenylenediamines had a significant effect on the resulting regioselectivity apart from the resulting yield. For example, a 4-methyl-substituted *o*-phenylenediamine **1d** could give two regioisomers in high yield (total yield of 95%), albeit at the expense of low regioselectivity (**3v**:**3′v** = 62:38, entry 7, Table 3). In contrast, when a 4-chloro-substituted *o*-phenylenediamine **1e** was used, the reaction gave two regioisomers in a total yield of 66%, albeit with a regioselectivity as high as 94:6 (**3w**:**3′w**, entry 8, Table 3). Similar results were obtained in the case of 4-bromo- or 4-nitro-substituted *o*-phenylenediamine (entries 9, 10, Table 3).

Table 2. Gold(I)-Catalyzed Reaction of *o*-Phenylenediamine 1a with Terminal Alkynes 2[a]




| entry | alkyne (2), $R^2$ = | product (3) | yield (%)[b] |
|---|---|---|---|
| 1 | **2a**: $C_6H_5$ | **3a** | 93 |
| 2 | **2b**: 4-$CH_3C_6H_4$ | **3b** | 92 |
| 3 | **2c**: 4-$C_2H_5C_6H_4$ | **3c** | 83 |
| 4 | **2d**: 4-$CH_3OC_6H_4$ | **3d** | 81 |
| 5 | **2e**: 4-$C_2H_5OC_6H_4$ | **3e** | 85 |
| 6 | **2f**: 4-$ClC_6H_4$ | **3f** | 96 |
| 7 | **2g**: 3-$ClC_6H_4$ | **3g** | 79[c] |
| 8 | **2h**: 2-$ClC_6H_4$ | **3h** | 51[c] |
| 9 | **2i**: 4-$BrC_6H_4$ | **3i** | 97 |
| 10 | **2j**: 4-$FC_6H_4$ | **3j** | 96 |
| 11 | **2k**: 2-thiophenyl | **3k** | 97 |
| 12 | **2l**: cyclopropyl | **3l** | 96 |
| 13 | **2m**: *n*-$C_4H_9$ | **3m** | 46[c] |
| 14 | **2n**: *n*-$C_6H_{13}$ | **3n** | 48[c] |
| 15 | **2o** =  |  **3o** | 0 |

[a]All reactions were carried out with **1a** (0.2 mmol) and **2** (0.5 mmol) in the presence of (2-biphenyl)$Cy_2PAuNTf_2$ (5.0 mol % based on **1a**) in $CHCl_3$ (2.0 mL) at 60 °C for 6 h unless otherwise noted. [b]Isolated yields. [c]The reaction time was 10 h.

To elucidate the mechanism of the reaction, we synthesized compound **6a** according to reported procedures.[16] When **6a** was subjected to the standard reaction conditions, **3a** could also be obtained in 95% yield (Scheme 2), suggesting that **6a** was likely a key intermediate for the reaction. Based on this result and previous reports,[7b,11b−d] a proposed mechanism regarding the gold(I)-catalyzed tandem amination/cyclization reaction of *o*-phenylenediamines with alkynes is depicted in Scheme 3. First, the hydroamination reaction between *o*-phenylenediamines and two molecules of alkynes to produce dienamine **5** occurs in the presence of gold(I).[11b,c] Then, dienamine **5** may undergo isomerization to form diimine **6** or monoimine **7** via double- or mono-1,3-shift of the hydrogen of the amino group.[11b,c] Finally, an intramolecular cyclization of monoimine **7** occurs to furnish seven-membered ring product **3**.[7b,f,g,17c]

In summary, for the first time we have realized a new access to 1,5-benzodiazepines directly from *o*-phenylenediamines and alkynes with high atom-economy wherein (2-biphenyl)-$Cy_2PAuNTf_2$ displays a crucial role in achieving high efficiency for the reaction.

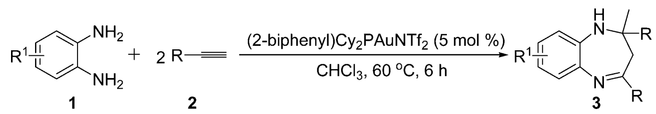
## ■ EXPERIMENTAL SECTION

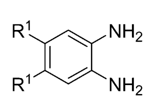
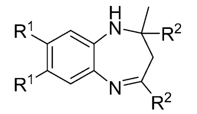
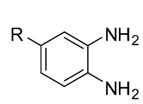
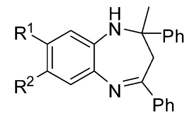
**General Methods.** Unless otherwise stated, all reagents were purchased from commercial suppliers and used without purifications. All solvents for the reactions were dried and distilled prior to use according to standard methods. Melting points were uncorrected. The $^1$H NMR and $^{13}$C NMR spectra were recorded at 25 °C in $CDCl_3$ at 500 and 125 MHz, respectively, with TMS as the internal standard. Chemical shifts ($\delta$) are expressed in ppm, and coupling constants $J$ are given in Hz. The IR spectra were recorded on an FT-IR spectrometer. GC−MS experiments were performed with EI source; high resolution mass spectra (HRMS) were obtained on a TOF MS instrument with EI source.

**General Procedure for the Gold(I)-Catalyzed Cycloaddition Reaction of *o*-Phenylenediamine (1) with Alkynes (2).** To a solution of *o*-phenylenediamine **1** (0.2 mmol) and alkynes **2** (0.5 mmol) in $CHCl_3$ (2.0 mL), (2-biphenyl)$Cy_2PAuNTf_2$ (0.01 mmol) was added. Then the reaction mixture was stirred at 60 °C for 6 h. Upon completion, the resulting mixture was diluted with $CH_2Cl_2$ and filtered through Celite. After evaporation of the solvent under vacuum, the residue was purified by column chromatography on silica gel (100−200 mesh) using petroleum ether−EtOAc (10:1, v/v) as eluent to give pure **3**.

*2-Methyl-2,4-diphenyl-2,3-dihydro-1H-1,5-benzodiazepine (3a).*[17a] Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a yellow soild (58.1 mg, 93%): IR (KBr) $\nu$ = 3336, 3057, 2971, 1606, 1469, 1331 cm$^{-1}$; $^1$H NMR ($CDCl_3$, 500 MHz) $\delta$ 7.60−7.57 (m, 4H), 7.33−7.15 (m, 7H), 7.07−7.03 (m, 2H), 6.83 (dd, $J_1$ = 1.5 Hz, $J_2$ = 7.5 Hz, 1H), 3.51 (br s, 1H), 3.13 (d, $J$ = 13.0 Hz, 1H), 2.97 (d, $J$ = 13.5 Hz, 1H), 1.75 (s, 3H); MS (EI, 70 eV) $m/z$ (%)

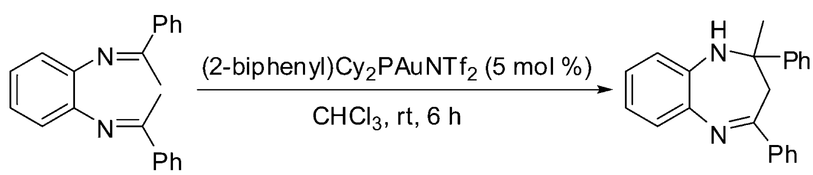
Table 3. Gold(I)-Catalyzed Synthesis of Other Substituted 1,5-Benzodiazepines[a]



| entry | diamine (1) | alkyne (2) | product (3) | yield (%)[b] |
|---|---|---|---|---|
| |  | |  | |
| 1 | $R^1 = CH_3$ (**1b**) | **2a** | $R^2 = C_6H_5$ (**3p**) | 91 |
| 2 | **1b** | **2b** | $R^2 = 4\text{-}CH_3C_6H_4$ (**3q**) | 95 |
| 3 | **1b** | **2f** | $R^2 = 4\text{-}ClC_6H_4$ (**3r**) | 98 |
| 4 | **1b** | **2l** | $R^2$ = cyclopropyl (**3s**) | 97 |
| 5 | $R^1$ = Cl (**1c**) | **2a** | $R^2 = C_6H_5$ (**3t**) | 67[c] |
| 6 | **1c** | **2j** | $R^2 = 4\text{-}FC_6H_4$ (**3u**) | 80[c] |
| |  | |  | |
| 7 | R = $CH_3$ (**1d**) | **2a** | $R^1 = CH_3$, $R^2$ = H (**3v**)<br>$R^1$ = H, $R^2 = CH_3$ (**3′v**) | 95<br>(**3v** : **3′v** = 62:38)[d] |
| 8 | R = Cl (**1e**) | **2a** | $R^1$ = Cl, $R^2$ = H (**3w**)<br>$R^1$ = H, $R^2$ = Cl (**3′w**) | 66<br>(**3w** : **3′w** = 94:6)[d] |
| 9 | R = Br (**1f**) | **2a** | $R^1$ = Br, $R^2$ = H (**3x**)<br>$R^1$ = H, $R^2$ = Br (**3′x**) | 72<br>(**3x** : **3′x** = 97:3)[d] |
| 10 | R = $NO_2$ (**1g**) | **2a** | $R^1 = NO_2$, $R^2$ = H (**3y**)<br>$R^1$ = H, $R^2 = NO_2$ (**3′y**) | 78[c]<br>(**3y** : **3′y** > 99:1)[d] |

[a]All reactions were carried out with **1** (0.2 mmol) and **2** (0.5 mmol) in the presence of (2-biphenyl)$Cy_2PAuNTf_2$ (5.0 mol % based on **1**) in $CHCl_3$ (2.0 mL) at 60 °C for 6 h unless otherwise noted. [b]Isolated yields. [c]The reaction time was 10 h. [d]The ratio was determined on the basis of $^1H$ NMR analysis.

Scheme 2. Conversion of 6a to 3a under the Standard Reaction Conditions



**6a** **3a** (yield: 95%)

= 312(35) [M$^+$], 297(38), 235(74), 194(100), 115(26), 77(64); mp 150−152 °C (lit.[17a] mp 150−152 °C).

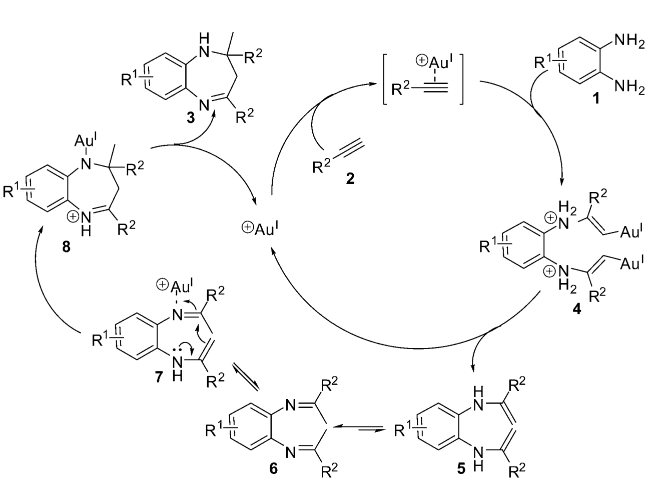
*2-Methyl-2,4-ditoluyl-2,3-dihydro-1H-1,5-benzodiazepine (**3b**).*[17a] Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a yellow solid (62.6 mg, 92%): IR (KBr) $\nu$ = 3336, 2969, 2921, 1604, 1415, 1329 cm$^{-1}$; $^1H$ NMR ($CDCl_3$, 500 MHz) $\delta$ 7.59−7.35 (m, 5H), 7.11−7.04 (m, 6H), 6.84 (dd, $J_1$ = 1.5 Hz, $J_2$ = 7.5 Hz, 1H), 3.54 (br s, 1H), 3.10 (d, $J$ = 13.5 Hz, 1H), 3.00 (d, $J$ = 13.5 Hz, 1H), 2.36 (s, 3H), 2.32 (s, 3H), 1.75 (s, 3H); MS (EI, 70 eV) $m/z$ (%) = 340(34) [M$^+$], 325(42), 249(45), 208(100), 91(16), 77(24); mp 99−100 °C (lit.[17a] mp 98−99 °C).

*2-Methyl-2,4-bis(4-ethylphenyl)-2,3-dihydro-1H-1,5-benzodiazepine (**3c**).* Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a yellow oil (61.2 mg, 83%): IR (neat) $\nu$ = 3337, 3050, 2966, 1606, 1510, 1315 cm$^{-1}$; $^1H$ NMR ($CDCl_3$, 500 MHz) $\delta$ 7.59−7.52 (m, 4H), 7.37−7.30 (m, 1H), 7.12−7.04 (m, 6H), 6.85 (dd, $J_1$ = 1.5 Hz, $J_2$ = 7.5 Hz, 1H), 3.56 (br s, 1H), 3.11 (d, $J$ = 13.0 Hz, 1H), 3.0 (d, $J$ = 13.0 Hz, 1H), 2.65−2.60 (m, 4H), 1.77 (s, 3H), 1.25−1.19 (m, 6H); $^{13}C$ NMR ($CDCl_3$, 125 MHz) $\delta$ 170.0, 145.2, 143.2, 138.4, 131.0, 128.6, 128.5, 128.1, 127.8, 127.6, 127.4, 126.3, 125.4, 121.6, 121.4, 77.5, 43.1, 29.8, 28.7, 28.4, 15.8, 15.4; MS (EI, 70 eV) $m/z$ (%) = 368(36) [M$^+$], 353(48), 263(42), 222(100), 131(18), 77(6); HRMS (EI) for $C_{26}H_{28}N_2$ calcd. 368.2252, found 368.2249.

*2-Methyl-2,4-bis(4-methoxyphenyl)-2,3-dihydro-1H-1,5-benzodiazepine (**3d**).*[17a] Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a yellow solid (60.3 mg, 81%): IR (KBr) $\nu$ = 3338, 3052, 2963, 1604, 1510, 1250 cm$^{-1}$; $^1H$ NMR ($CDCl_3$, 500 MHz) $\delta$ 7.63−7.32 (m, 5H), 7.07−7.06 (m, 2H), 6.84−6.78 (m, 5H), 3.82 (s, 3H), 3.78 (s, 3H), 3.44 (br s, 1H), 3.07 (d, $J$ = 13.5 Hz, 1H), 2.94 (d, $J$ = 13.5 Hz, 1H), 1.75 (s, 3H); MS (EI, 70 eV) $m/z$ (%) = 372(17) [M$^+$], 357(26), 253(10), 224(53), 207(100), 77(14); mp 118−120 °C (lit.[17a] mp 114−116 °C).

*2-Methyl-2,4-bis(4-ethoxyphenyl)-2,3-dihydro-1H-1,5-benzodiazepine (**3e**).* Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a brown solid (68.1 mg, 85%): IR (KBr) $\nu$ = 3347, 2977, 2927, 1604, 1510, 1469 cm$^{-1}$; $^1H$ NMR ($CDCl_3$, 500 MHz) $\delta$ 7.62−7.31 (m, 5H), 7.08−7.04 (m, 2H), 6.84−6.76 (m, 5H), 4.06−3.98 (m, 4H), 3.43 (br s, 1H), 3.06 (d, $J$ = 13.0 Hz, 1H), 2.93 (d,

**Scheme 3. Proposed Mechanism**



$J$ = 13.5 Hz, 1H), 1.74 (s, 3H), 1.44−1.38 (m, 6H); $^{13}$C NMR ($CDCl_3$, 125 MHz) $\delta$ 167.3, 160.5, 157.9, 140.6, 140.0, 138.1, 132.1, 128.9, 128.2, 126.6, 125.9, 121.8, 121.5, 114.2, 113.9, 73.4, 63.5, 42.8, 29.7, 14.8, 14.7; MS (EI, 70 eV) $m/z$ (%) = 400(32) [M$^+$], 385(43), 238(100), 207(28), 119(27), 77(6); HRMS (EI) for $C_{26}H_{28}N_2O_2$ calcd. 400.2151, found 400.2155; mp 104−106 °C.

*2-Methyl-2,4-bis(4-chlorophenyl)-2,3-dihydro-1H-1,5-benzodiazepine (**3f**).*[17a] Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a yellow solid (73.2 mg, 96%): IR (KBr) $\nu$ = 3338, 3061, 2972, 1599, 1481, 1328 cm$^{-1}$; $^1$H NMR ($CDCl_3$, 500 MHz) $\delta$ 7.56−7.49 (m, 4H), 7.33−7.31 (m, 1H), 7.24−7.21 (m, 4H), 7.13−7.06 (m, 2H), 6.85 (dd, $J_1$ =1.5, $J_2$ = 7.5 Hz, 1H), 3.45 (br s, 1H), 3.09 (d, $J$ = 13.5 Hz, 1H), 2.91 (d, $J$ = 13.5 Hz, 1H), 1.76 (s, 3H); MS (EI, 70 eV) $m/z$ (%) = 380(25) [M$^+$], 365(38), 228(100), 207(32), 102(13), 77(9); mp 144−146 °C (lit.[17a] mp 146−147 °C).

*2-Methyl-2,4-bis(3-chlorophenyl)-2,3-dihydro-1H-1,5-benzodiazepine (**3g**).*[7e] Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a yellow solid (60.2 mg, 79%): IR (KBr) $\nu$ = 3338, 3066, 2972, 1601, 1566, 1471 cm$^{-1}$; $^1$H NMR ($CDCl_3$, 500 MHz) $\delta$ 7.62−7.08 (m, 11H), 6.87 (dd, $J_1$ = 1.5 Hz, $J_2$ = 7.5 Hz, 1H), 3.48 (br s, 1H), 3.10 (d, $J$ = 13.5 Hz, 1H), 2.92 (d, $J$ = 13.0 Hz, 1H), 1.77 (s, 3H); MS (EI, 70 eV) $m/z$ (%) = 380(31) [M$^+$], 365(38), 269(78), 228(100), 102(12), 77(8); mp 104−106 °C.

*2-Methyl-2,4-bis(2-chlorophenyl)-2,3-dihydro-1H-1,5-benzodiazepine (**3h**).*[17b] Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a yellow solid (38.9 mg, 51%): IR (KBr) $\nu$ = 3293, 3061, 2967, 1619, 1476, 1432 cm$^{-1}$; $^1$H NMR ($CDCl_3$, 500 MHz) $\delta$ 7.77−7.75 (m, 1H), 7.31−6.85 (m, 10H), 6.26 (dd, $J_1$ = 1.5 Hz, $J_2$ = 7.5 Hz, 1H), 4.42 (d, $J$ = 13.5 Hz, 1H), 4.12 (br s, 1H), 2.97 (d, $J$ = 13.5 Hz, 1H), 1.90 (s, 3H); MS (EI, 70 eV) $m/z$ (%) = 380(37) [M$^+$], 365(100), 269(93), 152(54), 102(25), 77(20); mp 115−116 °C (lit.[17b] mp 114−115 °C).

*2-Methyl-2,4-bis(4-bromophenyl)-2,3-dihydro-1H-1,5-benzodiazepine (**3i**).*[17a] Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a brown solid (91.2 mg, 97%): IR (KBr) $\nu$ = 3337, 3059, 2970, 1607, 1478, 1392 cm$^{-1}$; $^1$H NMR ($CDCl_3$, 500 MHz) $\delta$ 7.49−7.31 (m, 9H), 7.28−7.06 (m, 2H), 6.85 (dd, $J_1$ = 1.5 Hz, $J_2$ = 7.5 Hz, 1H), 3.45 (br s, 1H), 3.08 (d, $J$ = 13.5 Hz, 1H), 2.90 (d, $J$ = 13.0 Hz, 1H), 1.75 (s, 3H); MS (EI, 70 eV) $m/z$ (%) = 470 (48) [M$^+$], 455(48), 274(100), 207 (56), 115(12), 77(6); mp 148−150 °C (lit.[17a] mp 145−146 °C).

*2-Methyl-2,4-bis(4-fluorophenyl)-2,3-dihydro-1H-1,5-benzodiazepine (**3j**).*[17a] Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a yellow solid (66.9 mg, 96%): IR (KBr) $\nu$ = 3334, 3064, 2971, 1603, 1506, 1228 cm$^{-1}$; $^1$H NMR ($CDCl_3$, 500 MHz) $\delta$ 7.60−7.38 (m, 5H), 7.14−7.07 (m, 2H), 6.95−6.87 (m, 5H), 3.48 (br s, 1H), 3.13 (d, $J$ = 13.5 Hz, 1H), 2.93 (d, $J$ = 13.0 Hz, 1H), 1.78 (s, 3H); MS (EI, 70 eV) $m/z$ (%) = 348(39) [M$^+$], 333(87), 253(39), 213(100), 95(10), 77(4); mp 106−107 °C (lit.[17a] mp 104−105 °C).

*2-Methyl-2,4-bis(thiophen-2-yl)-2,3-dihydro-1H-1,5-benzodiazepine (**3k**).*[17c] Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a brown solid (62.9 mg, 97%): IR (KBr) $\nu$ = 3335, 3072, 2971, 1593, 1467, 1429 cm$^{-1}$; $^1$H NMR ($CDCl_3$, 500 MHz) $\delta$ 7.42−7.35 (m, 2H), 7.13−6.94 (m, 7H), 6.85−6.84 (m, 1H), 3.64 (br s, 1H), 3.08 (d, $J$ = 13.5 Hz, 1H), 3.01 (d, $J$ = 13.5 Hz, 1H), 1.86 (s, 3H); MS (EI, 70 eV) $m/z$ (%) = 324(34) [M$^+$], 309(27), 241(10), 200(100), 109(2), 77(4); mp 90−91 °C (lit.[17c] mp 92−93 °C).

*2-Methyl-2,4-dicyclopropyl-2,3-dihydro-1H-1,5-benzodiazepine (**3l**).* Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a pale-yellow oil (46.1 mg, 96%): IR (neat) $\nu$ = 3341, 3078, 3004, 2961, 1628, 1471, 1307 cm$^{-1}$; $^1$H NMR ($CDCl_3$, 500 MHz) $\delta$ 7.08−7.06 (m, 1H), 6.94−6.93 (m, 2H), 6.70−6.69 (m, 1H), 2.88 (br s, 1H), 2.36 (d, $J$ = 12.5 Hz, 1H), 2.28 (d, $J$ = 13.0 Hz, 1H), 1.88−1.84 (m, 1H), 1.17 (s, 3H), 1.16−1.12 (m, 3H), 0.97−0.95 (m, 2H), 0.64−0.61 (m, 1H), 0.49−0.41 (m, 2H), 0.28−0.26 (m, 1H); $^{13}$C NMR ($CDCl_3$, 125 MHz) $\delta$ 175.7, 140.0, 137.8, 126.9, 124.9, 121.33, 121.28, 69.8, 43.5, 26.6, 22.4, 20.5, 9.8, 9.4, 1.2, 0.4; MS (EI, 70 eV) $m/z$ (%) = 240(45) [M$^+$], 225(32), 199(77), 183(16), 171(16), 158(100), 132(22), 77(12); HRMS (EI) for $C_{16}H_{20}N_2$ calcd. 240.1626, found 240.1624.

*2-Methyl-2,4-dibutyl-2,3-dihydro-1H-1,5-benzodiazepine (**3m**).*[17d] Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a yellow oil (25.1 mg, 46%): IR (neat) $\nu$ = 3343, 2958, 2929, 2865, 1681, 1638, 1468 cm$^{-1}$; $^1$H NMR ($CDCl_3$, 500 MHz) $\delta$ 7.15−7.13 (m, 1H), 6.99−6.97 (m, 2H), 6.73−6.71 (m, 1H), 3.10 (br s, 1H), 2.57 (t, $J$ = 7.8 Hz, 2H), 2.23 (d, $J$ = 13.0 Hz, 1H), 2.15 (d, $J$ = 12.5 Hz, 1H), 1.73−1.55 (m, 4H), 1.46−1.42 (m, 2H), 1.36−1.32 (m, 4H), 1.28 (s, 3H), 0.99−0.93 (m, 6H); MS (EI, 70 eV) $m/z$ (%) = 272(11) [M$^+$], 257(7), 175(44), 132(22), 92(7), 77(4).

*2-Methyl-2,4-dihexyl-2,3-dihydro-1H-1,5-benzodiazepine (**3n**).* Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a yellow oil (31.5 mg, 48%): IR (neat) $\nu$ = 3354, 2954, 2927, 2859, 1679, 1465, 1375 cm$^{-1}$; $^1$H NMR ($CDCl_3$, 500 MHz) $\delta$ 7.15−7.14 (m, 1H), 7.00−6.96 (m, 2H), 6.73−6.72 (m, 1H), 3.10 (br s, 1H), 2.57 (t, $J$ = 8.0 Hz, 2H), 2.23 (d, $J$ = 13.0 Hz, 1H), 2.15 (d, $J$ = 13.0 Hz, 1H), 1.74−1.53 (m, 4H), 1.43−1.38 (m, 2H), 1.35−1.31 (m, 12H), 1.28 (s, 3H), 0.92−0.89 (m, 6H); $^{13}$C NMR ($CDCl_3$, 125 MHz) $\delta$ 175.3, 140.8, 137.9, 127.1, 125.4, 121.8, 121.7, 70.7, 43.4, 42.9, 42.5, 31.8, 31.7, 29.8, 29.2, 27.6, 26.5, 24.2, 22.6, 14.1, 14.0; MS (EI, 70 eV) $m/z$ (%) = 328 (9) [M$^+$], 313(9), 243(100), 203(16), 173(67), 133(23), 77(4); HRMS (EI) for $C_{22}H_{36}N_2$ calcd. 328.2878, found 328.2875.

*2,7,8-Trimethyl-2,4-diphenyl-2,3-dihydro-1H-1,5-benzodiazepine (**3p**).*[17e] Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a yellow solid (62.0 mg, 91%): IR (KBr) $\nu$ = 3332, 2969, 2922, 1613, 1466, 1325 cm$^{-1}$; $^1$H NMR ($CDCl_3$, 500 MHz) $\delta$ 7.63−7.59 (m, 4H), 7.32−7.16 (m, 7H), 6.66 (s, 1H), 3.44 (br s, 1H), 3.15 (d, $J$ = 13.0 Hz, 1H), 2.98 (d, $J$ = 13.5 Hz, 1H), 2.28 (s, 6H), 1.77 (s, 3H); MS (EI, 70 eV) $m/z$ (%) = 340(45) [M$^+$], 325(68), 263(74), 222(100), 207(28), 77(23); mp 137−139 °C (lit.[17e] mp 136−138 °C).

*2,7,8-Trimethyl-2,4-ditoluyl-2,3-dihydro-1H-1,5-benzodiazepine (**3q**).*[17c] Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a yellow solid (70.0 mg, 95%): IR (KBr) $\nu$ = 3286, 2969, 2918, 1608, 1471, 1324 cm$^{-1}$; $^1$H NMR ($CDCl_3$, 500 MHz) $\delta$ 7.58 (d, $J$ = 7.0 Hz, 2H), 7.48 (d, $J$ = 6.0 Hz, 2H), 7.18−7.09 (m, 5H), 6.64 (s, 1H), 3.45 (br s, 1H), 3.10 (d, $J$ = 12.0 Hz, 1H), 2.98 (d, $J$ = 13.0 Hz, 1H), 2.35 (s, 3H), 2.31 (s, 3H), 2.26 (s, 6H), 1.73 (s, 3H); MS (EI, 70 eV) $m/z$ (%) = 368(26) [M$^+$], 353(30), 250(11), 236(100), 207(39), 77(10); mp 145−146 °C (lit.[17c] mp 142−144 °C).

*2,7,8-Trimethyl-2,4-bis(4-chlorophenyl)-2,3-dihydro-1H-1,5-benzodiazepine (**3r**).*[17c] Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a yellow solid (80.2 mg, 98%): IR (KBr) $\nu$ = 3278, 2969, 2917, 1591, 1481, 1317 cm$^{-1}$; $^1$H NMR ($CDCl_3$, 500 MHz) $\delta$ 7.53−7.48 (m, 4H), 7.23−7.16 (m, 5H), 6.65 (s, 1H), 3.38

(br s, 1H), 3.09 (d, $J$ = 13.0 Hz, 1H), 2.89 (d, $J$ = 13.5 Hz, 1H), 2.26 (s, 6H), 1.74 (s, 3H); MS (EI, 70 eV) $m/z$ (%) = 408(8) [M$^+$], 393(11), 256(9), 207(100), 133(11), 77(5); mp 183−184 °C (lit.[17c] mp 182−184 °C).

*2,4-Dicyclopropyl-2,7,8-trimethyl-2,3-dihydro-1H-1,5-benzodiazepine (**3s**).* Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a yellow oil (52.1 mg, 97%): IR (neat) $\nu$ = 3441, 3081, 3003, 2923, 1628, 1450, 1305 cm$^{-1}$; $^1$H NMR (CDCl$_3$, 500 MHz) $\delta$ 6.87 (s, 1H), 6.50 (s, 1H), 2.79 (br s, 1H), 2.34 (d, $J$ = 12.5 Hz, 1H), 2.26 (d, $J$ = 12.5 Hz, 1H), 2.18 (s, 6H), 1.89−1.85 (m, 1H), 1.16−1.10 (m, 6H), 0.95−0.94 (m, 2H), 0.62−0.58 (m, 1H), 0.49−0.40 (s, 2H), 0.28−0.25 (m, 1H); $^{13}$C NMR (CDCl$_3$, 125 MHz) $\delta$ 175.2, 137.7, 135.6, 133.3, 129.5, 128.1, 122.5, 69.6, 43.6, 26.5, 22.5, 20.6, 19.2, 18.8, 9.7, 9.3, 1.3, 0.6; MS (EI, 70 eV) $m/z$ (%) = 268(43) [M$^+$], 253(32), 227(29), 199(12), 186(100), 171(10), 160(12), 77(8); HRMS (EI) for $C_{18}H_{24}N_2$ calcd. 268.1939, found 268.1944.

*2-Methyl-2,4-diphenyl-2,3-dihydro-7,8-dichloro-1H-1,5-benzodiazepine (**3t**).*[17a] Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a yellow solid (51.1 mg, 67%): IR (KBr) $\nu$ = 3305, 3059, 2969, 1605, 1454, 1324 cm$^{-1}$; $^1$H NMR (CDCl$_3$, 500 MHz) $\delta$ 7.57−7.55 (m, 4H), 7.43 (s, 1H), 7.36−7.20 (m, 6H), 6.95 (s, 1H), 3.63 (br s, 1H), 3.30 (d, $J$ = 13.5 Hz, 1H), 2.99 (d, $J$ = 13.5 Hz, 1H), 1.78 (s, 3H); MS (EI, 70 eV) $m/z$ (%) = 380(50) [M$^+$], 365(42), 303(74), 207(100), 103(46), 77(35); mp 161−162 °C (lit.[17a] mp 158−160 °C).

*2-Methyl-2,4-bis(4-fluorophenyl)-2,3-dihydro-7,8-dichloro-1H-1,5-benzodiazepine (**3u**).* Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a yellow solid (66.8 mg, 80%): IR (KBr) $\nu$ = 3336, 3051, 2956, 1606, 1482, 1227 cm$^{-1}$; $^1$H NMR (CDCl$_3$, 500 MHz) $\delta$ 7.55−7.45 (m, 5H), 6.97−6.91 (m, 5H), 3.59 (br s, 1H), 3.16 (d, $J$ = 13.5 Hz, 1H), 2.91 (d, $J$ = 13.5 Hz, 1H), 1.78(s, 3H); $^{13}$C NMR (CDCl$_3$, 125 MHz) $\delta$ 167.9, 164.3 (d, $J$ = 251.3 Hz), 162.0 (d, $J$ = 246.3 Hz), 142.2, 137.4, 134.6, 131.0 (d, $J$ = 10.0 Hz), 129.6, 129.4 (d, $J$ = 8.8 Hz), 127.2 (d, $J$ = 8.8 Hz), 124.7, 122.1, 115.7 (d, $J$ = 10.0 Hz), 115.3 (d, $J$ = 21.3 Hz), 115.2 (d, $J$ = 21.3 Hz), 73.0, 43.4, 30.0; MS (EI, 70 eV) $m/z$ (%) = 416(53) [M$^+$], 401(42), 281(100), 207(44), 95(16), 77(3); HRMS (EI) for $C_{22}H_{16}Cl_2F_2N_2$ calcd. 416.0659, found 416.0662; mp 179−180 °C.

*2,8-Dimethyl-2,4-diphenyl-2,3-dihydro-1H-1,5-benzodiazepine (**3v**) and 2,7-Dimethyl-2,4-diphenyl-2,3-dihydro-1H-1,5-benzodiazepine (**3′v**).*[17f] Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a yellow solid (62.0 mg, 95%, **3v**:**3′v** = 62:38): $^1$H NMR (CDCl$_3$, 500 MHz) $\delta$ 7.64−7.58 (m, 4H), 7.33−7.18 (m, 7H), 6.92 (dd, $J_1$ = 2.0 Hz, $J_2$ = 8.0 Hz, 0.38H, **3′v**), 6.87 (dd, $J_1$ = 1.0 Hz, $J_2$ = 8.0 Hz, 0.62H, **3v**), 6.78 (d, $J$ = 7.5 Hz, 0.38H, **3′v**), 6.68 (s, 0.62H, **3v**), 3.51 (br s, 1H), 3.17 (d, $J$ = 13.0 Hz, 0.62H, **3v**), 3.13 (d, $J$ = 13.0 Hz, 0.38H, **3′v**), 3.00 (d, $J$ = 13.0 Hz, 0.62H, **3v**), 2.98 (d, $J$ = 13.0 Hz, 0.38H, **3′v**), 2.37 (s, 1.86H, **3v**), 2.36 (s, 1.14H, **3′v**), 1.78 (s, 1.86H, **3v**), 1.76 (s, 1.14H, **3′v**).

*2-Methyl-2,4-diphenyl-2,3-dihydro-8-chloro-1H-1,5-benzodiazepine (**3w**) and 2-Methyl-2,4-diphenyl-2,3-dihydro-7-chloro-1H-1,5-benzodiazepine (**3′w**).*[17f] Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a yellow solid (45.8 mg, 66%, **3w**:**3′w** = 94:6): $^1$H NMR (CDCl$_3$, 500 MHz) $\delta$ 7.59−7.56 (m, 4H), 7.35−7.19 (m, 7H), 7.06−7.04 (q, 0.06H, **3′w**), 7.02−7.00 (q, 0.94H, **3w**), 6.87 (d, $J$ = 2.0 Hz, 0.94H, **3w**), 6.79 (d, $J$ = 8.0 Hz, 0.06H, **3′w**), 3.64 (br s, 0.94H, **3w**), 3.53 (br s, 0.06H, **3′w**), 3.21 (d, $J$ = 13.5 Hz, 0.94H, **3w**), 3.16 (d, $J$ = 13.5 Hz, 0.06H, **3′w**), 3.00 (d, $J$ = 13.5 Hz, 0.94H, **3w**), 2.98 (d, $J$ = 13.5 Hz, 0.06 H, **3′w**), 1.79 (s, 2.82 H, **3w**), 1.77 (s, 0.18H, **3′w**).

*2-Methyl-2,4-diphenyl-2,3-dihydro-8-bromo-1H-1,5-benzodiazepine (**3x**) and 2-Methyl-2,4-diphenyl-2,3-dihydro-7-bromo-1H-1,5-benzodiazepine (**3′x**).*[17g] Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a yellow solid (61.4 mg, 72%, **3x**:**3′x** = 97:3): $^1$H NMR (CDCl$_3$, 500 MHz) $\delta$ 7.58−7.56 (m, 4H), 7.34−7.14 (m, 8H), 7.01 (d, $J$ = 2.0 Hz, 1 H), 3.61 (br s, 0.97H, **3x**), 3.55 (br s, 0.03H, **3′x**), 3.19 (d, $J$ = 13.5 Hz, 1H, **3x** plus **3′x**), 2.99 (d, $J$ = 13.5 Hz, 1H, **3x** plus **3′x**), 1.78 (s, 2.91H, **3x**), 1.77 (s, 0.09H, **3′x**).

*2-Methyl-2,4-diphenyl-2,3-dihydro-8-nitro-1H-1,5-benzodiazepine (**3y**) and 2-Methyl-2,4-diphenyl-2,3-dihydro-7-nitro-1H-1,5-benzodiazepine (**3′y**).*[17a] Purification by column chromatography (petroleum ether/EtOAc, 10/1) as a yellow solid (55.8 mg, 78%, **3y**:**3′y** > 99:1); data of **3y**: $^1$H NMR (CDCl$_3$, 500 MHz) $\delta$ 8.31 (d, $J$ = 2.5 Hz, 1H), 7.95 (dd, $J_1$ = 2.5 Hz, $J_2$ = 8.5 Hz, 1H), 7.62−7.60 (m, 2H), 7.40−7.35 (m, 3H), 7.31−7.23 (m, 4H), 7.20−7.17 (m, 1H), 6.82 (d, $J$ = 9.0 Hz, 1 H), 4.74 (br s, 1H), 3.43 (d, $J$ = 13.5 Hz, 1H), 3.11 (d, $J$ = 14.0 Hz, 1H), 1.83 (s, 3H).

## ■ ASSOCIATED CONTENT

### Supporting Information

Optimization of reaction conditions; copies of $^1$H NMR and/or $^{13}$C NMR of the products. This material is available free of charge via the Internet at http://pubs.acs.org.

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### Notes

The authors declare no competing financial interest.

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