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Hydrazone Radical Promoted Vicinal Difunctionalization of Alkenes and Trifunctionalization of Allyls: Synthesis of Pyrazolines and Tetrahydropyridazines

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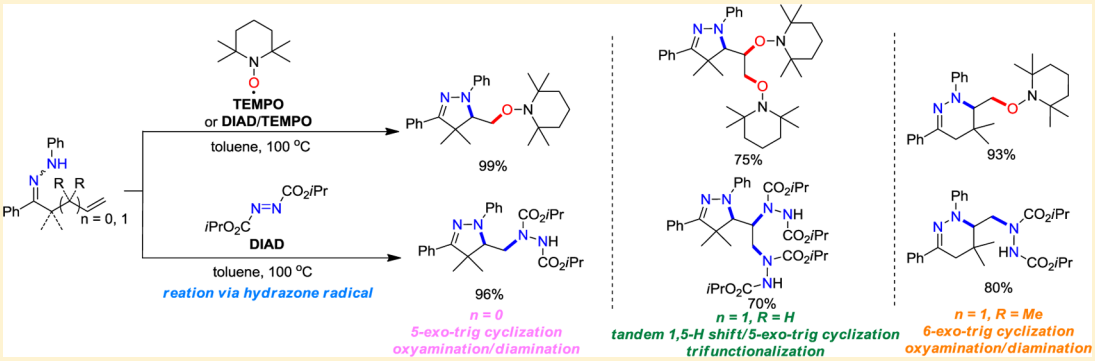
Supporting Information



ABSTRACT: The intramolecular addition of hydrazone radicals to carbon−carbon double bonds was achieved by using TEMPO (2,2,6,6-tetramethyl-1-piperidinyloxy) or DIAD (diisopropyl azodicarboxylate) as the hydrazone radical initiator as well as the carbon radical scavenger. Consequently, alkenes were difunctionalized to afford pyrazolines and tetrahydropyridazines via C−N forming 5-*exo-trig* and 6-*exo-trig* cyclizations, respectively, and allyls were trifunctionalized to afford pyrazolines via C−N forming tandem 1,5-H-shift/5-*exo-trig* cyclizations under metal-free neutral conditions.

INTRODUCTION

Free radical cyclizations have found wide applications in the synthesis of carbocyclic and heterocyclic compounds.[1] In this context, cyclization involving nitrogen-centered radical reactions constitutes one important strategy for the preparation of nitrogen-containing heterocycles such as pentazanes, lactams, and alkaloids.[2] The nitrogen-centered radicals can be accessed in many ways, among which the directed N−H bond activation/oxidation provides a facile and atom-economical method.[3] However, this methodology is limited to the generation of amidyl and sulfonylamidyl radicals; its applicability to other types of nitrogen-centered radicals have been scarcely reported.

Very recently, we reported a unique oxime radical-involved cyclization for the synthesis of isoxazolines and cyclic nitrones using TEMPO (2,2,6,6-tetramethyl-1-piperidinyloxy) and DEAD (diethyl azodicarboxylate) as the oxime radical initiator and carbon-centered radical scavenger.[4] One interesting part of this work is that oxime radicals were found to behave as σ radicals in the reaction with the spin densities delocalized on both oxygen and nitrogen atoms.[4] As a logical extension to this study, we found that hydrazones could also be converted to hydrazone radicals using TEMPO and DIAD (diisopropyl azodicarboxylate) as the radical initiator.[5] Herein, we report hydrazone radical participation in the vicinal difunctionalization of alkenes and trifunctionalization of allyls to synthesize pyrazolines and tetrahydropyridazines from β,γ-unsaturated and γ,δ-unsaturated hydrazones, respectively, through C−N forming 5-*exo-trig* and 6-*exo-trig* cyclization and tandem 1,5-H-shift/5-*exo-trig* cyclization under metal-free neutral conditions (Scheme 1).[6]

RESULTS AND DISCUSSION

At the beginning of this study, we anticipated that TEMPO[7] might oxidize β,γ-unsaturated hydrazones to hydrazone radicals by a hydrogen atom abstraction (HAT) process.[4,8] The formed hyadrazone radicals would undergo 5-*exo-trig* cyclization to give the corresponding carbon-centered radicals which could be trapped immediately by TEMPO to produce pyrazoline derivatives. With this in mind, we set out by treating a mixture of the β,γ-unsaturated hydrazone **1a** with TEMPO (3 equiv) in toluene at 100 °C under argon. As expected, the desired reaction took place, generating the TEMPO-trapped pyrazoline **2a** in quantitative yield (Scheme 2, condition A).

Next, when diisopropyl azodicarboxylate (DIAD, 2.0 equiv) was used as the radical initiator, the DIAD-trapped product **3a** was obtained in 96% yield (Scheme 2, condition B). Pyrazoline is an important structure motif which appears in many bioactive compounds,[9] and its construction has long been of interest to synthetic chemists.[10] The reactions described herein provide a simple and convenient protocol to gain access to the pyrazoline

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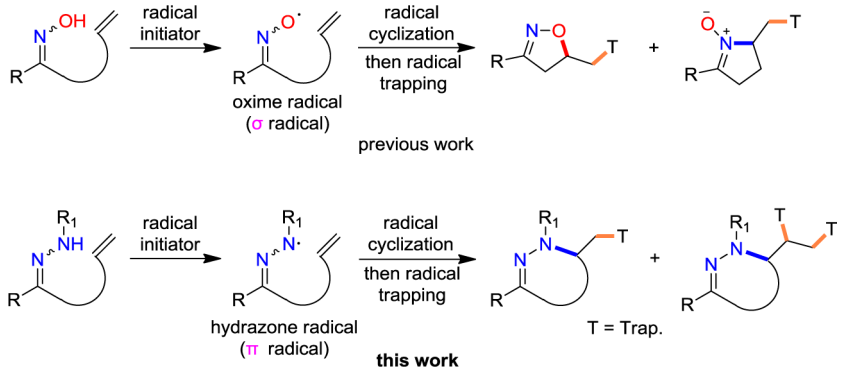
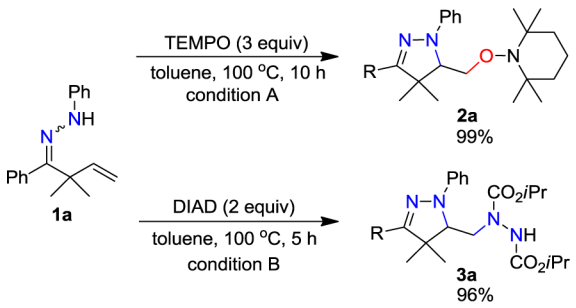
Scheme 1. Hydrazone Radical Cyclization



Scheme 2. TEMPO- or DIAD-Initiated Hydrazone Radical 5-*exo-trig* Cyclization



ring. In addition, the formation of compounds **2a** and **3a** involves the oxyamination and diamination of unactivated alkenes, two types of reactions which are of synthetic significance.[11]

To examine the scope of the present protocols, a variety of *β,γ*-unsaturated hydrazones were subjected to the aforementioned reaction conditions, and the results are summarized in Table 1. Compounds **1b**−**1j** reacted very well under both conditions, giving rise to the corresponding oxyamination and diamination products **2** and **3** in excellent yields (Table 1, entries 2−16). Both aromatic- and aliphatic-substituted hydrazones were tolerated. Indole-incorporated hydrazone **1l** was also transformed into the desired product in excellent yield (Table 1, entry 17). When *tert*-butyl-containing hydrazone **1m** was subjected to condition A, the normal product pyrazoline **2m** was obtained in 68% yield accompanied by further aromatized product pyrazole **2m′** in 7% yield (Table 1, entry 18). When the alkene moiety was incorporated in a ring, as in the cases of **1n**,**1o**, the reaction afforded the trans oxyamination and diamination products with high stereoselectivity (Table 1, entries 19−21). Apparently, the trapping of the cyclization-derived carbon radicals was more favored from the less hindered exo direction. Notably, the reaction could also be easily carried out on a gram scale without difficulty, thereby delivering **2b** and **3b** in excellent yield.

Having successfully achieved the 5-*exo-trig* radical cyclization of *β,γ*-unsaturated hydrazones, we moved on to extend the protocol to *γ,δ*-unsaturated hydrazones to see if the latter compounds could undergo 6-*exo-trig* N−C bond formation to form tetrahydropyridazines or 5-*exo-trig* N−C bond formation to produce azomethine imines,[12] which are analogues of the nitrones in our previous report.[4] However, neither tetrahydropyridazine nor azomethine imine was obtained when compound **1p** was used as the substrate under condition A. Instead, we obtained the double-TEMPO-trapped allyl trifunctionalized pyrazoline **2p** and its diasteroisomer **2p′**, in a combined yield of 30%, and recovered **1p**. The ratio of **2p** to **2p′** was 95:5. The structure of compound **2p** was confirmed by an X-ray single-crystal diffraction study (Scheme 3).[13] When sufficient TEMPO (6 equiv) was used in the reaction, **2p** was obtained in 51% yield.

To further improve the yield of product **2p**, DIAD (1 equiv) and TEMPO (4 equiv) were used as the hydrazone radical initiators as condition C. To our delight, the yield of the product **2p** increased to 75% under the aforementioned conditions also with high stereoselectivity (Scheme 3). This phenomenon demonstrates clearly that DIAD is more effective than TEMPO in initiating hydrazones to hyadrazone radicals, which is similar to the initiation of oximes to oxime radicals in our previous study.[4] This procedure not only provides a simple and convenient method to construct pyrazoline rings but also provides also an efficient method to trifunctionalize the allyl group. This result is totally different from what was obtained with the oxime analogue of **1p**, indicating that hydrazone radicals do not behave as *σ* radicals.[4]

To account for the aforementioned results, a mechanism was proposed as shown in Scheme 4. We believe that TEMPO initially abstracts an H atom from the N−H bond of hydrazone to produce the hydrazone radical **I**, which subsequently undergoes a 1,5-H shift from the C−H bond of the allyl group to produce allylic radical **II**.[14] Radical **II** is then trapped immediately by TEMPO to produce intermediate **III**, which reacts with TEMPO again via the same process to produce the hydrazone radical **IV**. The latter subsequently undergoes 5-*exo-trig* cyclization to form the radical intermediate **V**. The observed stereoselectivity can be explained with the model shown in Figure 1. In this model, the carbon radical intermediate **V** reacts with TEMPO in either conformer **V** or **V′**, of which conformer **V** is of lower energy. TEMPO is expected to attack the carbon radical from the direction away from the pyrazoline ring to avoid the steric repulsion. The formation of **2p**, which resulted from the trapping of conformer **V** by TEMPO, is preferred according to the Curtin−Hammett principle.[15]

Theoretical calculations on the energy profile for the 6-*exo-trig* cyclization and 1,5-H shift processes of the intermediate **I** also indicate that the 1,5-H shift of allylic hydrogen through **TS1** is more favored than C−N bond forming 6-exo cyclization through **TS2** by 2.4 kcal/mol in terms of free activation energy (Figure 2, top).[16] Such an energy difference explains well why the reaction of compound **1p** failed to deliver the 6-*exo-trig* cyclization products. In addition, our computational study also gave the spin densities of the hydrazone radical **I**. The single-electron spin density located on the N(1) atom is 0.60, and that located on the N(2) atom is nearly 0 (Figure 2, bottom). Obviously, the N(2)

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Table 1. Hydrazone Radical Promoted Intramolecular Vicinal Difunctionalization of Alkenes to Synthesis of Pyrazolines[a]

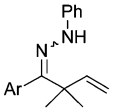
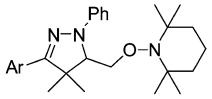
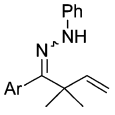
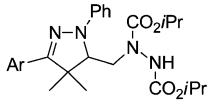
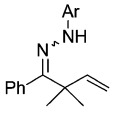
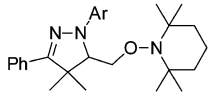
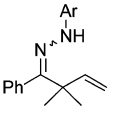
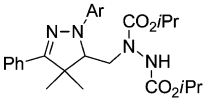
entry	substrate	conditions[b]	product	yield[c] (%)
		A		
1	Ar = Ph, **1a**		Ar = Ph, **2a**	99
2	4-MeOPh, **1b**		4-MeOPh, **2b**	93[d]
3	4-MePh, **1c**		4-MePh, **2c**	96
4	4-ClPh, **1d**		4-ClPh, **2d**	98
5	4-CNPh, **1e**		4-CNPh, **2e**	91
6	4-CF_3Ph, **1f**		4-CF_3Ph, **2f**	90
		B		
7	Ar = Ph, **1a**		Ar = Ph, **3a**	96
8	4-MeOPh, **1b**		4-MeOPh, **3b**	88[d]
9	4-CNPh, **1e**		4-CNPh, **3e**	92
		A		
10	Ar = 4-MeOPh, **1g**		Ar = 4-MeOPh, **2g**	99
11	4-MePh, **1h**		4-MePh, **2h**	98
12	4-ClPh, **1i**		4-ClPh, **2i**	94
13	4-CNPh, **1j**		4-CNPh, **2j**	92
14	4-CF_3Ph, **1k**		4- CF_3Ph, **2k**	89
		B		
15	Ar = 4-MeOPh, **1g**		Ar = 4-MeOPh, **3g**	93
16	4-CNPh, **1j**		4-CNPh, **3j**	89

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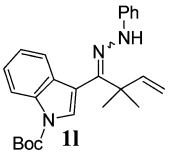
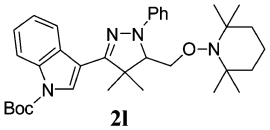
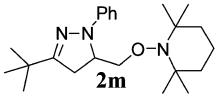
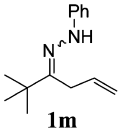
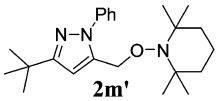
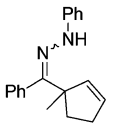
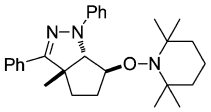
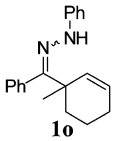
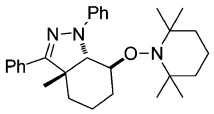
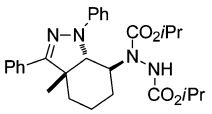
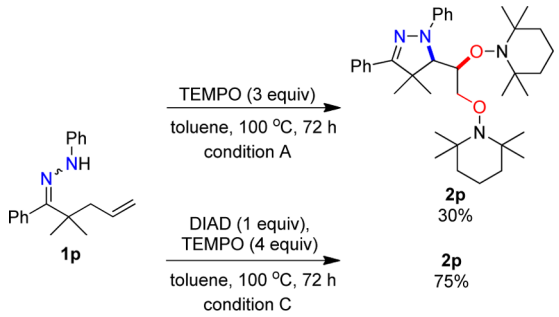
Table 1. continued

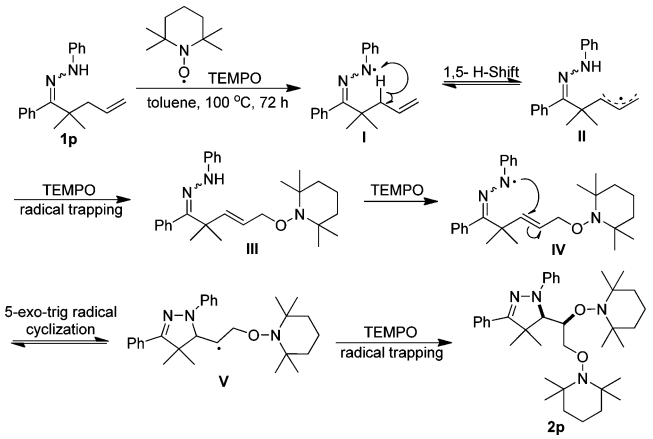
entry	substrate	conditions[b]	product	yield[c] (%)
17	 **1l**	A	 **2l**	90
			 **2m**	68
18	 **1m**	A	 **2m'**	7
19	 **1n**	A	 **2n**	95, dr 95:5[e]
20	 **1o**	A	 **2o**	96, dr 95:5[e,f]
21		B	 **3o**	89, dr 95:5[e,f]

[a]All reactions run in 0.5 M toluene using hydrazone **1** (0.5 mmol) at 100 °C after 10−24 h. [b]Condition A: TEMPO (1.5 mmol) was used. Condition B: DIAD (1.0 mmol) was used. [c]Yield of isolated product. [d]On a gram scale (5 mmol of hydrazone was used). [e]The diastereomeric ratios were determined by ^{1}H NMR spectroscopy of crude reaction mixtures. [f]The configuration of the diastereomer was confirmed by NOE, and coupling constants were determined by ^{1}H NMR spectroscopy.

Scheme 3. Hydrazone Radical Tandem 1,5-H Shift/5-*exo-trig* Cyclization



Scheme 4. Plausible Mechanism for Hydrazone Radical Promoted Tandem 1,5-H Shift/5-*exo-trig* Cyclization



atom 5-*exo-trig* cyclization to form azomethine imine cannot happen. This result also proves that hydrazone radicals are π radicals rather than σ radicals (oxime radical).[4,5,17]

With the optimized conditions for the tandem 1,5-H shift/5-*exo-trig* cyclization in hand, we applied them to other γ,δ-unsaturated hydrazones. As shown in Table 2, in all of these cases, allyl trifunctionalized pyrazolines were obtained in good yields with excellent stereoselectivity. When substrate **1p** was

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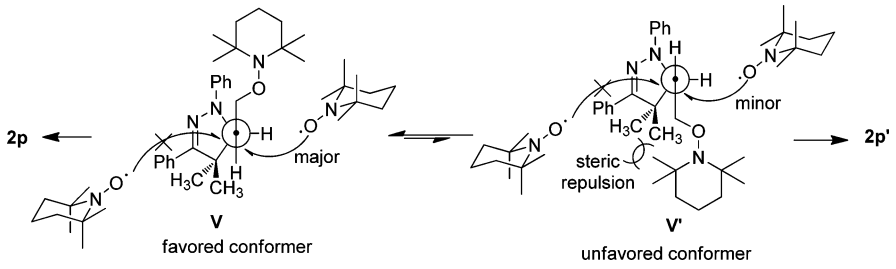

Figure 1. Rationalization of the high selectivity for the formation of **2p**.

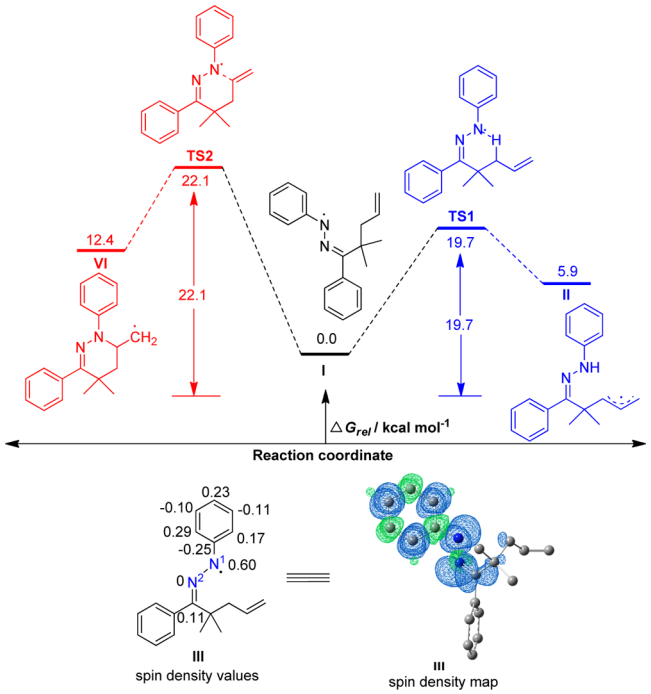

Figure 2. (top) Energy profiles for the hydrazone radical **I** N-atom 6-*exo* cyclization and N-atom 1,5 H-shift. The relative energies are given in kcal/mol. (bottom) Calculated Mulliken spin density values and the spin density map of the hydrazone radical **I**. Blue grid lines indicate regions of positive spin density.

used under condition B, the double-DIAD-trapped product pyrazoline **3p** was obtained in 70% yield (Table 2, entry 2). When biallyl incorporated hydrazone **1q** was used as the substrate under condition C, not only was allyl trifunctionalized pyrazoline **2q** obtained in 48% yield but also the radical cascaded product **4q** was obtained in 15% yield with excellent stereoselectivity (Table 2, entry 3). A plausible mechanism for the radical cascade reaction is shown in Scheme 5. When triallyl incorporated hydrazone **1r** was used, the radical cascade product **4r** was obtained as the major product in 45% yield with excellent stereoselectivity, similar to the reaction of **1q** as mentioned above (Table 2, entry 4).

As mentioned above, both our experiments and our theoretical calculations indicate that the 6-*exo* cyclization is unfavorable in comparison with the 1,5-hydrogen abstraction. We expected that, if the 1,5-hydrogen abstraction was made impossible, the 6-*exo-trig* cyclization would take place. Indeed, when substrate **1s** was subjected to both conditions A and B, the desired tetrahydropyridazines **2s** and **3s** were obtained in excellent yields, respectively (Scheme 6). The procedures were also applicable to several other γ,δ-unsaturated hydrazones. When methyl- and phenyl-substituted **1t** was used as the substrate, tetrahydropyridazines **2t** were obtained as diastereoisomers in the ratio 50:50 (Table 3, entry 3). The alkyl-containing substrate **1u** could also convert to **2u** in 60% yield (Table 3, entry 4).

In conclusion, we have demonstrated that the hydrazone radical-involved reactions could be of great synthetic value. Hydrazone radicals can be conveniently prepared from hydrazones by using commercially available TEMPO or DIAD as the radical initiator. By using this protocol, simple methods were developed for the synthesis of pyrazolines and tetrahydropyridazines from β,γ-unsaturated and γ,δ-unsaturated hydrazones, respectively, through C−N forming 5-*exo-trig* and 6-*exo-trig* cyclization and tandem 1,5-H-shift/5-*exo-trig* cyclization. TEMPO and DIAD act as carbon radical scavengers as well in the reactions, and consequently, oxyamination, diamination of unactivated alkenes, and dioxyamination and triamination of allyls can be realized. Further studies on the hydrazone radical-promoted reaction are in progress in our laboratory.

EXPERIMENTAL SECTION

General Methods. All reagents were purchased from commercial suppliers and used without further purification. Flash chromatography was carried out with silica gel (200−300 mesh). Analytical TLC was performed with silica gel GF254 plates, and the products were visualized by UV detection. Melting points were determined without correction on a digital melting-point apparatus. ^{1}H NMR and ^{13}C NMR (400 and 100 MHz, respectively) spectra were recorded in $CDCl_3$. Chemical shifts (δ) are reported in ppm using TMS as internal standard, and spin−spin coupling constants (J) are given in Hz. Infrared (IR) spectra were recorded in KBr tablets, and wavenumbers are given in cm^{-1}. EI-MS spectra were measured on a spectrometer by direct inlet at 70 eV. The high-resolution mass spectra (HRMS) were measured on an electrospray ionization (ESI) apparatus using time of flight (TOF) mass spectrometry. Data collections for crystal structure were performed at room temperature (293 K) using Mo Kα radiation on a diffractometer.

General Procedure for the Synthesis of Hydrazones 1a−f,l−q,s,t. To a solution of the ketone (1.0 mmol) in 5 mL of anhydrous ethanol was added arylhydrazine (1.5 mmol) and acetic acid (0.2 mmol). The mixture was stirred at reflux and monitored by TLC. Then the mixture was directly concentrated in vacuo. The crude material was purified by flash chromatography on silica gel to afford the hydrazone.[18]

General Procedure for the Synthesis of Hydrazones 1g−k,u. To a solution of the ketone (1.0 mmol) in 2 mL of anhydrous ethanol and acetic acid (0.2 mL) was added a solution of substituted phenylhydrazine hydrochloride (1.5 mmol) and Et_3N (0.2 mL, 1.5 mmol) in 3 mL of ethanol. The reaction mixture was stirred overnight at reflux and monitored by TLC. Then the mixture was directly concentrated in vacuo. The crude material was purified by flash chromatography on silica gel to afford the hydrazone.[18]

*1-(1-(4-Methoxyphenyl)-2,2-dimethylbut-3-en-1-ylidene)-2-phenylhydrazine (**1b**):* pale-yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.18 (td, J = 1.2 Hz, J = 7.2 Hz, 2H), 7.02−7.05 (m, 2H), 6.92−6.99 (m, 4H), 6.87 (br, 1H), 6.76 (t, J = 7.4 Hz, 1H), 6.00 (dd, J = 10.6 Hz, J = 17.4 Hz, 1H), 4.99 (m, 2H), 3.85 (s, 3H), 1.30 (s, 6H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 159.1, 152.2, 145.7, 145.4, 130.1, 129.1, 125.3, 119.2, 114.3, 112.5, 111.8, 55.22, 55.19, 44.3, 25.6; MS m/z (relative intensity, %) 294

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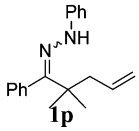
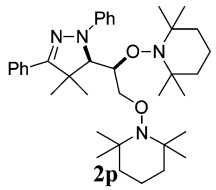
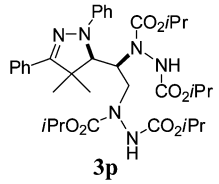
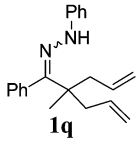
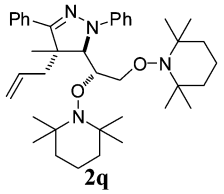
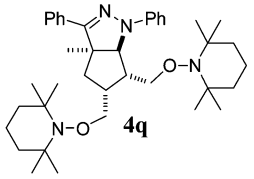
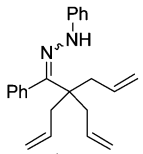
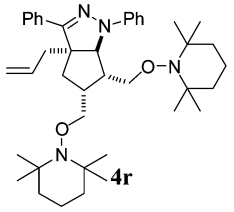
Table 2. Hydrazone Radical Promoted Intramolecular Vicinal Trifunctionalization of Allyls to Synthesis of Pyrazolines[a]

entry	substrate	conditions[b]	product	yield[c] (%)
1	 **1p**	C	 **2p**	75, dr 95: 5[d,e]
2[f]		B	 **3p**	70, dr 90: 10[d,e]
3	 **1q**	C	 **2q**	48, dr 95: 5[d,e]
			 **4q**	15, dr 95:5[d,e]
4[g]	 **1r**	C	 **4r**	45, dr 95: 5[d,e]

[a]Unless noted otherwise, the reactions were run in 0.5 M toluene using hydrazone **1** (0.5 mmol) at 100 °C for 72 h. [b]Condition C: DIAD (0.5 mmol) and TEMPO (2.0 mmol) were used. [c]Yield of isolated product. [d]The diastereomeric ratios were determined by ^{1}H NMR spectroscopy of crude reaction mixtures. [e]The configuration of the diastereomer was confirmed by NOE, and coupling constants were determined by ^{1}H NMR spectroscopy and an X-ray structure study. [f]DIAD (3.0 mmol) was used. [g]Substrate **1r** was generated in situ using the corresponding ketone (0.2 mmol), phenyl hydrazine (0.3 mmol) and HOAc (0.2 mmol) at 100 °C for 12 h and then reacted under condition C without isolation.

(53.0), 279 (56.2), 225 (16.9), 187 (15.1), 177 (15.4), 161 (33.4), 149 (13.86), 135 (53.1), 122 (8.8), 92 (100), 77 (14.2), 69 (13.2) 65 (21.1); ESI-HRMS m/z calcd for $C_{19}H_{22}N_2O$ + H^+ 295.1805, found 295.1810; FTIR (KBr, neat, cm^{-1}) ν 3318, 2969, 2931, 1600, 1503, 1287, 1247, 1174, 1108, 1065, 1027, 912, 832, 742, 691.

*1-(2,2-Dimethyl-1-(p-tolyl)but-3-en-1-ylidene)-2-phenylhydrazine (**1c**):* pale-yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.24 (dd, J = 2.0 Hz, J = 10.0 Hz, 2H), 7.17 (t, J = 8.0 Hz, 2H), 6.99 (d, J = 8.0 Hz, 2H), 6.92 (d, J = 8.0 Hz, 2H), 6.83 (br, 1H), 6.00 (dd, J = 6.8 Hz, J = 17.6 Hz, 1H), 4.96 (dd, J = 10.8 Hz, J = 28.4 Hz, 2H), 2.39 (s, 3H), 1.30 (s, 6H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 152.5, 145.7, 145.5, 138.3, 130.3, 129.6, 129.1, 128.7, 119.2, 112.6, 111.8, 44.2, 25.6, 21.3; MS m/z (relative intensity, %) 278 (55.5), 263 (80.2), 248 (4.0), 209 (17.9), 186 (11.3), 170 (11.4), 161 (25.7), 146 (19.5), 118 (20.0), 105 (6.3), 92 (100), 77 (8.4), 69 (12.6), 65 (29.2); ESI-HRMS m/z calcd for $C_{19}H_{22}N_2$ + H^+ 279.1856, found 279.1860; FTIR (KBr, neat, cm^{-1}) ν 3335, 2969, 2925, 2868, 1602, 1502, 1377, 1311, 1253, 1170, 1112, 1068, 1014, 914, 824, 749, 693.

*1-(1-(4-Chlorophenyl)-2,2-dimethylbut-3-en-1-ylidene)-2-phenylhydrazine (**1d**):* pale-yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43 (d, J = 8.4 Hz, 2H), 7.18 (t, J = 7.6 Hz, 2H), 7.05 (d, J = 8.4 Hz, 2H), 6.93 (d, J = 8.0 Hz, 2H), 6.76–6.80 (t, br, J = 7.6 Hz, 2H), 6.96 (dd, J = 10.8 Hz, J = 17.6 Hz, 1H), 4.94–5.03 (m, 2H), 1.30 (s, 6H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 150.8, 145.3, 145.2, 134.7, 131.7, 130.4, 129.3, 129.1, 119.6, 112.6, 112.3, 44.1, 25.6; MS m/z (relative intensity, %) 298 (20.4), 283 (35.9), 268 (1.6), 192 (21.7), 181 (9.0), 92 (100), 77 (5.3), 69 (10.5), 65 (22.7); ESI-HRMS m/z calcd for $C_{18}H_{19}ClN_2$ + H^+ 299.1310, found 299.1313; FTIR (KBr, neat, cm^{-1}) ν 3335, 2970, 2926, 2868, 1601, 1501, 1377, 1311, 1251, 1170, 1092, 1067, 1011, 916, 882, 832, 749, 692.

*4-(2,2-Dimethyl-1-(2-phenylhydrazono)but-3-en-1-yl)-benzonitrile (**1e**):* pale-yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.75 (d, J = 8.4 Hz, 2H), 7.26 (d, J = 8.4 Hz, 2H), 7.20 (d, J = 7.6 Hz, 2H), 6.94 (d, J = 7.6 Hz, 2H), 6.81 (t, J = 7.6 Hz, 1H), 5.94 (ddd, J = 1.2 Hz, J = 5.6 Hz, J = 10.4 Hz, 1H), 5.00 (m, 2H), 1.31 (s, 6H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 149.6, 144.9, 138.4, 132.6, 129.9, 129.1, 120.0, 118.2, 112.8, 112.71, 112.66, 44.1, 25.5; MS m/z (relative intensity, %) 289

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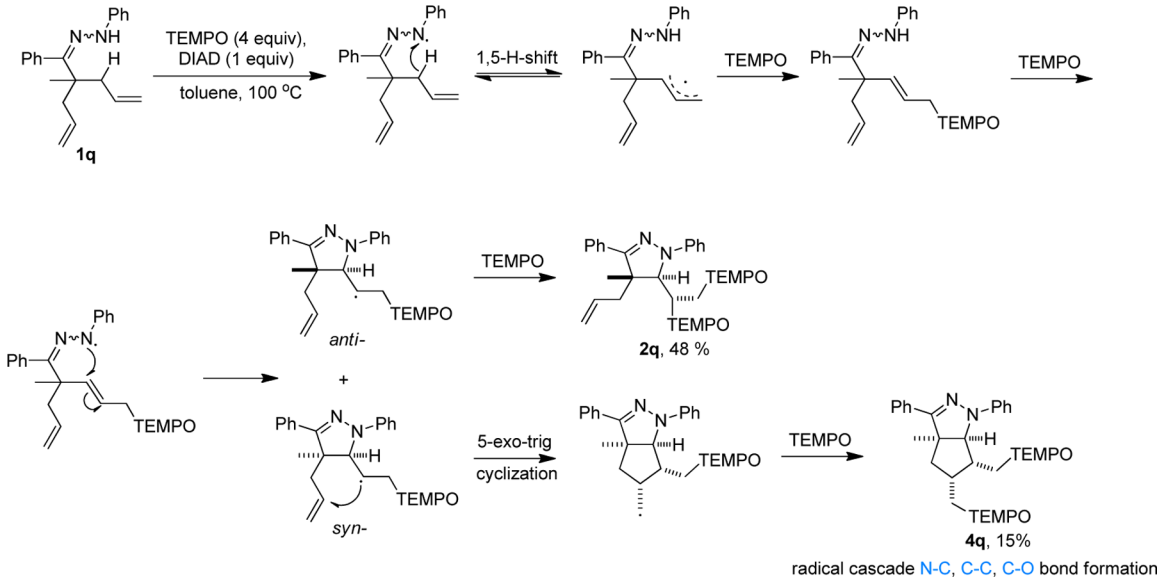
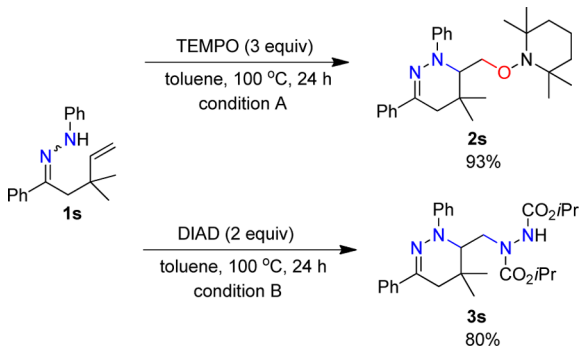
Scheme 5. DIAD/TEMPO-Initiated Hydrazone Radical Cascade Cyclization



Scheme 6. Hydrazone Radical Promoted *6-exo-trig* Cyclization



(42.9), 274 (80.9), 259 (6.0), 197 (10.7), 172 (18.2), 146 (13.8), 129 (12.0), 92 (100), 77 (9.6), 69 (15.7), 65 (39.6); ESI-HRMS m/z calcd for $C_{19}H_{19}N_3 + H^+$ 290.1652, found 290.1650; FTIR (KBr, neat, cm^{-1}) ν 3297, 2972, 2928, 2237, 1599, 1506, 1249, 1107, 1067, 1010, 922, 836, 750, 695, 576.

*1-(2,2-Dimethyl-1-(4-(trifluoromethyl)phenyl)but-3-en-1-ylidene)-2-phenylhydrazine (**1f**):* pale-yellow oil; ^1H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, J = 8.0 Hz, 2H), 7.30 (d, J = 8.0 Hz, 2H), 7.24 (td, J = 0.8 Hz, J = 7.6 Hz, 2H), 6.98 (d, J = 7.6 Hz, 2H), 6.84 (t, J = 7.2 Hz, 1H), 6.74 (br, 1H), 6.01 (dd, J = 6.8 Hz, J = 10.0 Hz, 1H), 4.99−5.09 (m, 2H), 1.35 (s, 6H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 150.4, 145.1, 145.0, 137.3, 130.8 (q, J = 33 Hz), 129.5, 129.1, 125.9 (q, J = 4 Hz), 123.9 (q, J = 271 Hz), 119.8, 112.65, 112.55, 44.1, 25.5; MS m/z (relative intensity, %) 332 (39.9), 317 (57.0), 240 (9.0), 215 (13.3), 199 (5.6), 173 (7.0), 146 (10.4), 118 (11.4), 92 (100), 77 (7.6), 69 (11.8), 65 (22.6); ESI-HRMS m/z calcd for $C_{19}H_{19}F_3N_2 + H^+$ 333.1573, found 333.1577; FTIR (KBr, neat, cm^{-1}) ν 3332, 2970, 2932, 1512, 1465, 1236, 1179, 1116, 1091, 1039, 914, 825, 765, 707, 521.

*1-(2,2-Dimethyl-1-phenylbut-3-en-1-ylidene)-2-(4-methoxyphenyl)hydrazine (**1g**):* pale-yellow oil; ^1H NMR (400 MHz, $CDCl_3$) δ 7.37−7.46 (m, 3H), 7.09−7.11 (m, 2H), 6.86−6.89 (m, 2H), 6.75−6.79 (m, 2H), 6.65 (br, 1H), 6.00 (dd, J = 10.0 Hz, J = 17.4 Hz, 1H), 4.94−5.01 (m, 2H), 3.73 (s, 3H), 1.30 (s, 6H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 153.2, 151.7, 145.6, 139.7, 133.5, 128.8, 128.4, 114.6, 113.7, 111.8, 55.7, 44.0, 25.6; MS m/z (relative intensity, %) 294 (75.6), 279 (14.5), 172 (6.9), 164 (4.6), 148 (4.5), 135 (5.8), 122 (100), 105 (25.3), 95 (13.8), 77 (19.5), 69 (15.0); ESI-HRMS m/z calcd for $C_{19}H_{22}N_2O + H^+$ 295.1805, found 295.1808; FTIR (KBr, neat, cm^{-1}) ν 3340, 2873, 2931, 1602, 1503, 1325, 1251, 1168, 1130, 1068, 1014, 918, 845, 750, 693.

*4-(2-(2,2-Dimethyl-1-phenylbut-3-en-1-ylidene)hydrazinyl)-benzonitrile (**1j**):* pale-yellow oil; ^1H NMR (400 MHz, $CDCl_3$) δ 7.42−7.50 (m, 5H), 7.09−7.11 (m, 3H), 5.98 (dd, J = 10.0 Hz, J = 17.4 Hz, 1H), 4.97−5.06 (m, 2H), 1.31 (s, 6H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 155.6, 148.2, 144.7, 133.5, 132.5, 129.04, 128.97, 128.5, 120.1, 112.5, 112.4, 101.1, 44.3, 25.4; MS m/z (relative intensity, %) 289 (36.1), 274 (100), 220 (33.1), 172 (15.3), 157 (20.8), 147 (15.8), 131 (13.7), 117 (, 62.2), 104 (15.8), 90 (36.9), 77 (15.7), 69 (17.8); ESI-HRMS m/z calcd for $C_{19}H_{19}N_3 + H^+$ 290.1652, found 290.1655; FTIR (KBr, neat, cm^{-1}) ν 3336, 3288, 2972, 2218, 1605, 1517, 1328, 1261, 1170, 1119, 1088, 1014, 914, 833, 781, 734, 706, 547.

*1-(2,2-Dimethyl-1-phenylbut-3-en-1-ylidene)-2-(4-(trifluoromethyl)phenyl)hydrazine (**1k**):* pale-yellow oil; ^1H NMR (400 MHz, $CDCl_3$) δ 7.39−7.49 (m, 5H), 7.00 (dd, J = 1.0 Hz, J = 7.8 Hz, 2H), 6.99 (br, 1H), 6.95 (d, J = 7.6 Hz, 2H), 6.00 (dd, J = 10.0 Hz, J = 17.4 Hz, 1H), 4.96−5.05 (m, 2H), 1.31 (m, 6H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 154.3, 147.7, 145.1, 132.9, 129.0, 128.8, 128.6, 126.4 (q, J = 4.0 Hz), 124.8 (q, J = 269 Hz), 120.9 (q, J = 32 Hz), 112.3, 112.0, 44.2, 25.5; MS m/z (relative intensity, %) 332 (29.0), 317 (100), 263 (36.7), 214 (8.1), 172 (14.8), 160 (74.9), 147 (21.8), 140 (43.9), 131 (16.1), 104 (15.3), 91 (11.4), 77 (11.8), 69 (16.3); ESI-HRMS m/z calcd for $C_{19}H_{19}F_3N_2 + H^+$ 333.1573, found 333.1575; FTIR (KBr, neat, cm^{-1}) ν 3341, 2974, 2932, 1615, 1529, 1480, 1324, 1261, 1161, 1115, 1063, 916, 835, 706.

*1-(2,2-Dimethyl-1-phenylpent-4-en-1-ylidene)-2-phenylhydrazine (**1p**):* pale-yellow oil; ^1H NMR (400 MHz, $CDCl_3$) δ 7.40−7.46 (m, 3H), 7.11−7.19 (m, 4H), 6.89−6.92 (m, 2H), 6.74−6.78 (m, 2H), 5.89−5.99 (m, 1H), 5.03−5.08 (m, 2H), 2.33 (d, J = 7.2 Hz, 2H), 1.17 (s, 6H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 153.2, 145.4, 135.7, 133.5, 129.10, 129.07, 128.65, 128.53, 119.2, 117.0, 112.5, 44.9, 40.5, 26.3; MS m/z (relative intensity, %) 278 (59.3), 277 (100), 237 (73.9), 222 (27.6), 195 (26.8), 173 (47.5), 158 (22.3), 144 (31.1), 134 (86.5), 104 (47.9), 92 (70.0), 77 (46.5), 65 (62.4); ESI-HRMS m/z calcd for $C_{19}H_{22}N_2 + H^+$ 279.1856, found 279.1859; FTIR (KBr, neat, cm^{-1}) ν 3336, 2965, 2925, 1601, 1503, 1298, 1252, 1112, 1066, 1017, 914, 778, 748, 702.

*1-(2-Allyl-2-methyl-1-phenylpent-4-en-1-ylidene)-2-phenylhydrazine (**1q**):* pale-yellow oil; ^1H NMR (400 MHz, $CDCl_3$) δ 7.50−7.39 (m, 3H), 7.20−7.12 (m, 4H), 6.91 (d, J = 7.6 Hz, 2H), 6.79−6.75 (m, 2H), 5.99−5.88 (m, 2H), 5.09−5.05 (m, 4H), 2.40 (dd, J = 7.0 Hz, J = 14.6 Hz, 2H), 2.29 (dd, J = 7.4 Hz, J = 14.2 Hz, 2H), 1.09 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 151.3, 145.3, 135.4, 133.3, 129.2, 129.1, 128.61, 128.55, 119.3, 117.3, 112.5, 43.9, 42.9, 23.6; MS m/z (relative intensity,

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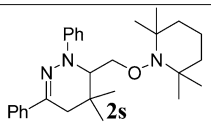
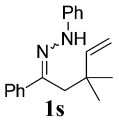
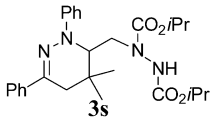
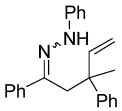
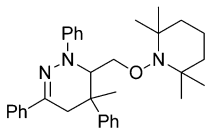
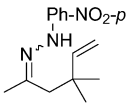
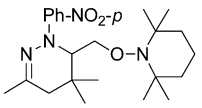
Table 3. Hydrazone Radical Promoted Intramolecular Difunctionalization of Alkenes to Synthesis of Tetrahydropyridazines[a]

entry	substrate	conditions[b]	product	yield[c] (%)
1		A	 **2s**	93
2	 **1s**	B	 **3s**	80
3	 **1t**	A	 **2t+2t'**	88, dr 50:50[d]
4[e]	 **1u**	A	 **2u**	60

[a]All reactions were run in 0.5 M toluene using hydrazone **1** (0.5 mmol) at 100 °C. [b]Condition A: TEMPO (1.5 mmol) was used. Condition B: DIAD (1.0 mmol) was used. [c]Yield of isolated product. [d]The diastereomeric ratios were determined by ^{1}H NMR spectroscopy of crude reaction mixtures.

%) 304 (31.4), 263 (100), 249 (7.2), 235 (3.7), 221 (10.6), 212 (12.2), 195 (15.9), 170 (37.1), 158 (37.8), 129 (6.4), 106 (25.6), 104 (22.4), 92 (50.3), 77 (21.3), 65 (24.3); ESI-HRMS m/z calcd for $C_{21}H_{24}N_2 + H^+$ 305.2012, found 305.2013; FTIR (KBr, neat, cm^{-1}) ν 3336, 3074, 2974, 2928, 1601, 1503, 1437, 1252, 1112, 1067, 996, 778, 749, 703.

*1-(3,3-Dimethyl-1-phenylpent-4-en-1-ylidene)-2-phenylhydrazine (**1s**; Z/E Mixture 2/1):* pale-yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.75 (d, J = 7.6 Hz, 6H), 7.43 (d, J = 7.6 Hz, 2H), 7.35 (t, J = 7.6 Hz, 4H), 7.30−7.20 (m, 7H), 7.18 (d, J = 7.6 Hz, 2H), 7.10 (d, J = 7.6 Hz, 4H), 6.95 (d, J = 8.0 Hz, 2H), 6.86 (t, J = 7.6 Hz, 2H), 6.78 (t, J = 7.2 Hz, 1H), 5.93 (dd, J = 10.8 Hz, J = 13.6 Hz, 2H), 5.77 (dd, J = 10.8 Hz, J = 13.6 Hz, 1H), 5.12−4.99 (m, 4H), 4.86−4.75 (m, 2H), 2.76 (s, 4H), 2.65 (s, 2H), 1.08 (s, 12H), 1.02 (s, 6H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 148.1, 148.0, 145.2, 145.12, 145.06, 143.3, 140.3, 135.4, 129.2, 129.14, 129.10, 128.6, 128.2, 127.9, 127.7, 126.2, 125.3, 120.0, 119.4, 113.0, 112.6, 111.5, 110.0, 50.4, 38.3, 38.0, 37.6, 28.0, 27.2; MS m/z (relative intensity, %) 278 (17.5), 263 (4.3), 209 (52.0), 173 (14.0), 167 (12.7), 145 (13.7), 120 (33.8), 105 (100), 91 (11.3), 77 (49.2), 69 (24.3); ESI-HRMS m/z calcd for $C_{19}H_{22}N_2 + H^+$ 279.1856, found 279.1858; FTIR (KBr, neat, cm^{-1}) ν 3339, 3055, 2963, 2929, 1601, 1498, 1252, 1146, 1070, 1007, 915, 749, 693.

*1-(3-Methyl-1,3-diphenylpent-4-en-1-ylidene)-2-phenylhydrazine (**1t**):* pale-yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 (d, J = 7.2 Hz, 4H), 7.42 (d, J = 7.6 Hz, 4H), 7.37−7.30 (m, 10H), 7.27−7.21 (m, 5H), 7.20−7.05 (m, 10H), 7.01 (d, J = 6.8 Hz, 2H), 6.82−6.68 (m, 10H), 6.20−6.05 (m, 3H), 5.21−5.16 (m, 4H), 5.03−4.99 (m, 2H), 3.28 (d, J = 14.4 Hz, 2H), 3.09 (d, J = 14.0 Hz, 3H), 1.45 (s, 3H), 1.36 (s, 6H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 146.8, 146.7, 146.6, 145.1, 145.0, 144.1, 142.9, 140.5, 135.2, 129.0, 128.9, 128.8, 128.78, 128.3, 128.1, 127.8, 127.64, 127.60, 127.1, 126.7, 126.5, 126.2, 125.7, 119.7, 119.3, 112.9, 112.6, 112.4, 111.8, 49.1, 44.7, 38.3, 29.6, 25.7, 25.4; MS m/z (relative intensity, %) 340 (11.5), 235 (8.1), 220 (6.3), 209 (100), 167 (13.9), 131 (14.8), 106 (20.2), 91 (11.9), 77 (13.7), 65 (4.5); ESI-HRMS m/z calcd for $C_{24}H_{24}N_2 + H^+$ 341.2012, found 341.2015; FTIR (KBr, neat, cm^{-1}) ν 3332, 3083, 3056, 3025, 2972, 2928, 1680, 1600, 1497, 1445, 1337, 1314, 1252, 1144, 1072, 1027, 1001, 911, 754, 733, 696, 647, 536.

*1-(4,4-Dimethylhex-5-en-2-ylidene)-2-(4-nitrophenyl)hydrazine (**1u**):* pale-yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.13 (t, J = 4.6 Hz, 2H), 7.55 (br, 1H), 7.04 (d, J = 9.2 Hz, 2H), 5.92 (dd, J = 10.6 Hz, J = 17.8 Hz, 1H), 4.95 (dd, J = 3.6 Hz, J = 15.6 Hz, 2H), 2.36 (s, 2H), 1.90 (s, 3H), 1.10 (s, 6H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 150.4, 149.0, 147.8, 139.7, 126.1, 111.7, 110.7, 51.6, 37.4, 27.0, 17.0; MS m/z (relative intensity, %) 261 (28.9), 246 (8.2), 215 (5.3), 191 (28.7), 176 (9.1), 151 (100), 145 (24.1), 110 (4.8), 105 (20.8), 91 (4.6), 77 (3.9), 69 (29.0); ESI-HRMS m/z calcd for $C_{14}H_{19}N_3O_2 + H^+$ 262.1550, found 262.1553; FTIR (KBr, neat, cm^{-1}) ν 3332, 2962, 2926, 1740, 1599, 1522, 1502, 1476, 1320, 1271, 1174, 1110, 1090, 1000, 914, 842, 752, 694.

General Experimental Procedure. *Condition A.* A mixture of hydrazone (0.5 mmol) and TEMPO (1.5 mmol) was placed in a 10-mL Schlenk tube in toluene (1 mL) and stirred at 100 °C under argon. When the starting materials were consumed completely as monitored by TLC, the reaction mixture was subjected to silica gel column chromatography to give the corresponding product. The identity and purity of the product were confirmed by ^{1}H and ^{13}C NMR spectroscopic analysis.

Condition B. A mixture of hydrazone (0.5 mmol) and DIAD (1.0 mmol) was placed in a 10-mL Schlenk tube in toluene (1 mL) and stirred at 100 °C under argon. When the starting materials were consumed completely as monitored by TLC, the reaction mixture was subjected to silica gel column chromatography to give the product. The identity and purity of the product were confirmed by ^{1}H and ^{13}C NMR spectroscopic analysis.

Condition C. A mixture of hydrazone (0.5 mmol), DIAD (0.5 mmol), and TEMPO (2.0 mmol) was placed in a 10-mL Schlenk tube in toluene (1 mL) and stirred at 100 °C under argon. When the starting materials were consumed completely as monitored by TLC, the reaction mixture was subjected to silica gel column chromatography to give the product. The identity and purity of the product were confirmed by ^{1}H and ^{13}C NMR spectroscopic analysis.

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*1-((4,4-Dimethyl-1,3-diphenyl-4,5-dihydro-1H-pyrazol-5-yl)-methoxy)-2,2,6,6-tetramethylpiperidine (**2a**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (207.4 mg, 99% yield) after flash chromatography (hexanes/EtOAc, 40:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.75 (t, J = 6.8 Hz, 2H), 7.39−7.27 (m, 3H), 7.25−7.22 (m, 4H), 6.83 (t, J = 6.6 Hz, 1H), 4.04−3.99 (m, 3H), 1.53 (s, 3H), 1.49 (s, 3H), 1.41−1.39 (m, 4H), 1.30−1.26 (m, 2H), 1.20 (s, 3H), 1.08 (s, 3H), 1.06 (s, 3H), 1.00 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 155.7, 145.2, 132.7, 128.8, 128.3, 128.2, 126.9, 119.5, 114.8, 73.9, 70.8, 59.8, 59.7, 49.9, 39.8, 33.1, 33.0, 29.7, 27.6, 20.4, 20.1, 19.9, 17.0; MS m/z (relative intensity, %) 419 (6.9), 263 (100), 249 (33.0), 221 (34.2), 189 (1.5), 160 (20.5), 104 (13.2), 91 (7.9), 77 (17.5), 69 (9.7), 57 (5.3); ESI-HRMS m/z calcd for $C_{27}H_{37}N_3O^+$ 419.2931, found 419.2934; FTIR (KBr, neat, cm^{-1}) ν 2972, 2930, 1597, 1498, 1465, 1384, 1256, 1133, 1034, 993, 955, 930, 875, 745, 693.

*Diisopropyl 1-((4,4-Dimethyl-1,3-diphenyl-4,5-dihydro-1H-pyrazol-5-yl)methyl) hydrazine-1,2-dicarboxylate (**3a**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (223.7 mg, 96% yield) after flash chromatography (hexanes/EtOAc, 5:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (d, J = 7.2 Hz, 2H), 7.40−7.33 (m, 3H), 7.28−7.18 (m, 4H), 6.84 (t, J = 7.2 Hz, 1H), 6.43−6.12 (brs, 1H), 4.98−4.91 (m, 2H), 4.28 (s, 1H), 3.98 (s, 1H), 3.49 (s, 1H), 1.49 (s, 3H), 1.43 (s, 3H), 1.26−1.19 (m, 12H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 155.7, 144.6, 132.3, 129.1, 128.4, 128.3, 126.8, 119.5, 114.0, 70.9, 70.2, 70.0, 68.1, 49.8, 48.4, 29.6, 27.1, 22.0, 21.9, 21.8, 21.7, 18.7, 14.1; MS m/z (relative intensity, %) 466 (5.6), 365 (1.1), 279 (5.1), 263 (15.4), 249 (100), 233 (1.6), 217 (1.4), 194 (2.0), 163 (1.2), 155 (2.8), 131 (3.5), 97 (3.6), 77 (5.4), 71 (7.1), 57 (7.6); ESI-HRMS m/z calcd for $C_{26}H_{34}N_4O_4$ + H$^+$ 467.2653, found 467.2658; FTIR (KBr, neat, cm^{-1}) ν 3305, 2981, 2934, 2253, 1719, 1597, 1499, 1469, 1386, 1231, 1180, 1108, 1035, 939, 913, 836, 766, 747, 733, 695, 669, 648, 506.

*1-((3-(4-Methoxyphenyl)-4,4-dimethyl-1-phenyl-4,5-dihydro-1H-pyrazol-5-yl)methoxy)-2,2,6,6-tetramethylpiperidine (**2b**).* The title compound was prepared according to the general procedure and isolated as a colorless solid (1.044 g, 93% yield) after flash chromatography (hexanes/EtOAc, 40:1) mp 117−119 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69 (d, J = 8.8 Hz, 2H), 7.27−7.20 (m, 4H), 6.90 (d, J = 9.2 Hz, 2H), 6.82 (t, J = 6.8 Hz, 1H), 4.03−4.02 (m, 2H), 3.98−3.95 (m, 1H), 3.83 (s, 3H), 1.52 (s, 3H), 1.47 (s, 3H), 1.45−1.40 (m, 4H), 1.30−1.26 (m, 2H), 1.20 (s, 3H), 1.08 (s, 3H), 1.06 (s, 3H), 1.00 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 159.4, 155.4, 145.1, 128.5, 128.0, 124.9, 119.0, 114.4, 113.5, 73.7, 70.3, 59.5, 59.4, 55.0, 49.6, 39.4, 39.3, 32.8, 32.6, 27.3, 20.0, 19.8, 19.7, 16.7; MS m/z (relative intensity, %) 449 (30.5), 293 (100), 279 (61.3), 251 (15.0), 225 (23.2), 219 (47.9), 191 (89.5), 161 (41.3), 149 (30.4), 135 (90.0), 126 (42.0), 109 (18.8), 91 (24.6), 77 (30.5), 69 (40.3); ESI-HRMS m/z calcd for $C_{28}H_{39}N_3O_2^+$ 449.3037, found 449.3037; FTIR (KBr, neat, cm^{-1}) ν 2972, 2932, 1598, 1499, 1465, 1387, 1301, 1251, 1176, 1132, 1035, 991, 955, 910, 834, 745, 733, 693, 587.

*Diisopropyl 1-((3-(4-Methoxyphenyl)-4,4-dimethyl-1-phenyl-4,5-dihydro-1H-pyrazol-5-yl)methyl)hydrazine-1,2-dicarboxylate (**3b**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (1.091 g, 88% yield) after flash chromatography (hexanes/EtOAc, 5:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 (d, J = 8.8 Hz, 2H), 7.27−7.23 (m, 2H), 7.17 (d, J = 8.0 Hz, 2H), 6.91 (d, J = 8.8 Hz, 2H), 6.83 (t, J = 7.2 Hz, 1H), 6.43−6.16 (brs, 1H), 4.98−4.90 (m, 2H), 4.26 (s, 1H), 4.01 (s, 1H), 3.83 (s, 3H), 3.57−3.47 (m, 1H), 1.48 (s, 3H), 1.41 (s, 3H), 1.26−1.23 (m, 12H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 159.9, 156.3, 155.6, 144.9, 129.1, 128.5, 128.2, 127.6, 124.7, 119.4, 113.8, 72.2, 70.9, 70.1, 69.9, 68.1, 55.2, 49.8, 48.4, 29.6, 27.1, 22.3, 22.0, 21.9, 21.8, 21.6, 18.8; MS m/z (relative intensity, %) 496 (7.2), 437 (0.8), 395 (1.0), 279 (100), 264 (3.2), 249 (2.2), 194 (8.8), 165 (2.9), 130 (2.3), 118 (2.1), 85 (6.6), 71 (6.6); ESI-HRMS m/z calcd for $C_{27}H_{36}N_4O_5$ + H$^+$ 497.2758, found 497.2761; FTIR (KBr, neat, cm^{-1}) ν 3303, 2980, 2934, 1715, 1598, 1499, 1467, 1384, 1253, 1177, 1108, 1036, 941, 835, 750, 695, 628, 592, 517.

*1-((4,4-Dimethyl-1-phenyl-3-(p-tolyl)-4,5-dihydro-1H-pyrazol-5-yl)methoxy)-2,2,6,6-tetramethylpiperidine (**2c**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (207.8 mg, 96% yield) after flash chromatography (hexanes/EtOAc, 40:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 (d, J = 8.0 Hz, 2H), 7.27−7.16 (m, 6H), 6.82 (t, J = 6.6 Hz, 1H), 4.03−3.97 (m, 3H), 2.36 (s, 3H), 1.52 (s, 3H), 1.47 (s, 3H), 1.41−1.39 (m, 4H), 1.28−1.26 (m, 2H), 1.20 (s, 3H), 1.08 (s, 3H), 1.06 (s, 3H), 1.00 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 155.8, 145.3, 138.1, 129.7, 129.0, 128.8, 126.8, 119.3, 114.7, 73.9, 70.6, 59.7, 59.6, 49.8, 39.7, 33.1, 32.9, 29.6, 27.6, 21.3, 21.2, 20.3, 20.0, 19.9, 17.0; MS m/z (relative intensity, %) 433 (9.5), 277 (100), 263 (54.6), 235 (28.1), 209 (20.1), 172 (31.5), 160 (34.1), 149 (82.5), 118 (30.6), 91 (12.6), 77 (24.4), 69 (28.5), 57 (32.0); ESI-HRMS m/z calcd for $C_{28}H_{39}N_3O^+$ 433.3088, found 433.3082; FTIR (KBr, neat, cm^{-1}) ν 2972, 2929, 1733, 1597, 1498, 1465, 1383, 1264, 1132, 1035, 995, 955, 931, 819, 745, 693.

*Diisopropyl 1-((3-(4-Cyanophenyl)-4,4-dimethyl-1-phenyl-4,5-dihydro-1H-pyrazol- 5-yl)methyl)hydrazine-1,2-dicarboxylate (**3c**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (225.9 mg, 92% yield) after flash chromatography (hexanes/EtOAc, 5:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 (d, J = 8.4 Hz, 2H), 7.63 (d, J = 8.4 Hz, 2H), 7.28 (t, J = 8.4 Hz, 2H), 7.21 (d, J = 8.0 Hz, 2H), 6.90 (t, J = 7.2 Hz, 1H), 6.36−6.08 (brs, 1H), 5.00−4.91 (m, 2H), 4.35 (s, 1H), 3.95 (s, 1H), 3.49 (s, 1H), 1.53 (s, 3H), 1.44 (s, 3H), 1.27−1.22 (m, 12H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 155.5, 152.7, 143.7, 136.9, 132.1, 129.2, 126.7, 120.4, 118.9, 114.3, 111.1, 70.3, 70.0, 68.4, 49.4, 48.0, 29.6, 27.0, 22.0, 21.9, 21.8, 21.7, 18.6; MS m/z (relative intensity, %) 491 (6.2), 390 (1.2), 358 (2.0), 342 (1.7), 287 (2.6), 274 (100), 259 (2.1), 218 (1.9), 144 (1.3), 131 (2.4), 118 (1.5), 91 (1.7), 77 (3.4); ESI-HRMS m/z calcd for $C_{27}H_{33}N_5O_4$ + H$^+$ 492.2605, found 492.2609; FTIR (KBr, neat, cm^{-1}) ν 3309, 2981, 2932, 2226, 1737, 1715, 1597, 1497, 1469, 1386, 1264, 1227, 1175, 1142, 1107, 914, 841, 748, 734, 694.

*1-((3-(4-Chlorophenyl)-4,4-dimethyl-1-phenyl-4,5-dihydro-1H-pyrazol-5-yl)methoxy)-2,2,6,6-tetramethylpiperidine (**2d**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (222.2 mg, 98% yield) after flash chromatography (hexanes/EtOAc, 100:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68 (dd, J = 1.6 Hz, J = 6.8 Hz, 2H), 7.34−7.31 (m, 2H), 7.28−7.20 (m, 4H), 6.85 (t, J = 7.0 Hz, 1H), 4.05−3.99 (m, 3H), 1.52 (s, 3H), 1.47 (s, 3H), 1.40−1.30 (m, 4H), 1.29−1.26 (m, 2H), 1.19 (s, 3H), 1.06 (s, 3H), 1.03 (s, 3H), 0.98 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 154.4, 144.9, 134.0, 131.1, 128.9, 128.5, 128.0, 119.7, 114.8, 73.8, 70.8, 59.8, 59.7, 49.6, 39.7, 33.0, 29.7, 27.6, 20.3, 20.1, 19.8, 17.0; MS m/z (relative intensity, %) 455 (1.8), 453 (6.5), 299 (34.3), 297 (100), 283 (35.9), 255 (37.2), 192 (21.6), 160 (24.3), 118 (20.8), 77 (21.3), 69 (21.1), 57 (17.0); ESI-HRMS m/z calcd for $C_{27}H_{36}ClN_3O^+$ 453.2541, found 453.2546; FTIR (KBr, neat, cm^{-1}) ν 2971, 2929, 1598, 1496, 1464, 1382, 1265, 1134, 1092, 1065, 1036, 995, 955, 930, 831, 746, 693.

*4-(4,4-Dimethyl-1-phenyl-5-(((2,2,6,6-tetramethylpiperidin-1-yl)-oxy)methyl)-4,5-dihydro-1H-pyrazol-3-yl)benzonitrile (**2e**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (202.0 mg, 91% yield) after flash chromatography (hexanes/EtOAc, 10:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 (d, J = 8.0 Hz, 2H), 7.61 (d, J = 8.0 Hz, 2H), 7.29−7.22 (m, 4H), 6.88 (t, J = 6.8 Hz, 1H), 4.09−4.07 (m, 1H), 4.04−3.99 (m, 2H), 1.58 (s, 3H), 1.48 (s, 3H), 1.40−1.26 (m, 6H), 1.18 (s, 3H), 1.04 (s, 3H), 1.00 (s, 3H), 0.96 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 152.2, 143.5, 136.6, 131.5, 128.4, 126.1, 119.7, 119.4, 114.2, 110.2, 73.0, 70.6, 59.2, 59.1, 48.6, 39.1, 32.4, 32.3, 29.1, 27.0, 19.7, 19.4, 19.1, 16.4; MS m/z (relative intensity, %) 444 (10.7), 288 (96.2), 274 (82.1), 246 (39.8), 214 (100), 183 (9.2), 156 (90.1), 149 (65.2), 126 (46.2), 109 (25.7), 83 (41.8), 77 (25.3), 69 (75.8), 55 (74.5); ESI-HRMS m/z calcd for $C_{28}H_{36}N_4O^+$ 444.2884, found 444.2880; FTIR (KBr, neat, cm^{-1}) ν 2972, 2931, 2225, 1597, 1497, 1466, 1389, 1277, 1138, 1070, 1036, 911, 842, 746, 734, 693, 547.

*1-((4,4-Dimethyl-1-phenyl-3-(4-(trifluoromethyl)phenyl)-4,5-dihydro-1H-pyrazol-5-yl)methoxy)-2,2,6,6-tetramethylpiperidine (**2f**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (219.2 mg, 90% yield) after flash chromatography (hexanes/EtOAc, 100:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (d, J = 8.0 Hz, 2H), 7.60 (d, J = 8.0 Hz, 2H), 7.29−7.22 (m, 4H), 6.87 (t, J = 6.8 Hz, 1H), 4.06−4.00 (m, 3H), 1.56 (s, 3H), 1.49 (s, 3H), 1.41−1.26 (m, 6H), 1.19 (s, 3H), 1.06 (s, 3H), 1.03 (s, 3H), 0.98 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 153.2, 144.0, 135.7,

129.1 (q, J = 32 Hz), 128.4, 126.2, 124.7 (q, J = 4 Hz), 123.7 (q, J = 270 Hz), 119.5, 114.3, 73.2, 70.5, 59.3, 59.2, 49.0, 39.22, 39.19, 32.5, 29.2, 27.1, 19.8, 19.5, 19.3, 16.5; MS m/z (relative intensity, %) 332 (34.2), 317 (50.9), 240 (8.4), 215 (11.1), 173 (10.6), 146 (10.0), 118 (10.8), 92 (100), 77 (7.7), 69 (12.2), 65 (21.8); ESI-HRMS m/z calcd for $C_{28}H_{36}F_3N_3O^+$ 487.2805, found 487.2808; FTIR (KBr, neat, cm^{-1}) ν 2974, 2933, 1617, 1598, 1537, 1499, 1467, 1389, 1325, 1275, 1166, 1128, 1069, 1037, 1016, 993, 955, 909, 878, 844, 735, 692, 669, 649, 610, 593.

*1-((1-(4-Methoxyphenyl)-4,4-dimethyl-3-phenyl-4,5-dihydro-1H-pyrazol-5-yl)methoxy)-2,2,6,6-tetramethylpiperidine (**2g**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (222.3 mg, 99% yield) after flash chromatography (hexanes/EtOAc, 40:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, J = 7.6 Hz, 2H), 7.37−7.29 (m, 3H), 7.19 (d, J = 8.8 Hz, 2H), 6.85 (d, J = 8.4 Hz, 2H), 4.10−4.02 (m, 2H), 3.84 (t, J = 5.6 Hz, 1H), 3.78 (s, 3H), 1.52 (s, 3H), 1.48 (s, 3H), 1.42 (s, 4H), 1.31−1.26 (m, 2H), 1.14−1.08 (m, 9H), 1.01 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 155.71, 154.5, 140.0, 132.6, 128.2, 128.0, 126.8, 118.4, 114.1, 74.2, 72.3, 59.60, 55.5, 50.0, 39.6, 39.5, 33.2, 32.7, 29.6, 26.8, 20.2, 20.0, 19.6, 17.0; MS m/z (relative intensity, %) 449 (4.4), 294 (55.3), 279 (16.6), 188 (100), 149 (18.0), 126 (44.6), 105 (35.7), 77 (21.1), 71 (53.8), 57 (72.5); ESI-HRMS m/z calcd for $C_{28}H_{39}N_3O_2^+$ 449.3037, found 449.3045; FTIR (KBr, neat, cm^{-1}) ν 2973, 2931, 1582, 1510, 1466, 1376, 1242, 1181, 1133, 1041, 991, 909, 826, 766, 733, 695, 649, 593, 522.

*Diisopropyl 1-((1-(4-Methoxyphenyl)-4,4-dimethyl-3-phenyl-4,5-dihydro-1H-pyrazol-5-yl)methyl)hydrazine-1,2-dicarboxylate (**3g**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (230.6 mg, 93% yield) after flash chromatography (hexanes/EtOAc, 3:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 (d, J = 7.2 Hz, 2H), 7.38−7.32 (m, 3H), 7.18 (d, J = 7.6 Hz, 2H), 6.85 (d, J = 8.8 Hz, 2H), 6.23−6.02 (brs, 1H), 4.99−4.91 (m, 2H), 4.09−3.87 (m, 2H), 3.78 (s, 3H), 3.65 (s, 1H), 1.44 (s, 6H), 1.32−1.23 (m, 12H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 155.6, 154.7, 139.4, 132.4, 128.3, 126.8, 117.9, 114.5, 70.0, 55.6, 49.9, 29.7, 26.5, 22.0, 21.91, 21.88, 21.7, 18.8; MS m/z (relative intensity, %) 496 (12.5), 294 (1.5), 279 (100), 264 (1.8), 182 (5.2), 169 (1.7), 150 (10.5), 97 (5.4), 85 (11.6), 77 (12.4), 57 (12.9); ESI-HRMS m/z calcd for $C_{27}H_{36}N_4O_5$ + H^+ 497.2758, found 497.2766; FTIR (KBr, neat, cm^{-1}) ν 3304, 3053, 2981, 2932, 1714, 1601, 1511, 1467, 1406, 1385, 1263, 1241, 1180, 1107, 1040, 939, 913, 827, 766, 733, 696, 584.

*1-((4,4-Dimethyl-3-phenyl-1-(p-tolyl)-4,5-dihydro-1H-pyrazol-5-yl)methoxy)-2,2,6,6-tetramethylpiperidine (**2h**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (212.2 mg, 98% yield) after flash chromatography (hexanes/EtOAc, 40:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, J = 7.2 Hz, 2H), 7.37−7.28 (m, 3H), 7.15−7.05 (m, 4H), 4.04 (d, J = 5.6 Hz, 2H), 3.94 (t, J = 5.4 Hz, 1H), 2.27 (s, 3H), 1.52 (s, 3H), 1.49 (s, 3H), 1.41−1.40 (m, 4H), 1.30−1.26 (m, 2H), 1.93 (s, 3H), 1.08 (s, 6H), 1.02 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 155.3, 143.1, 132.7, 129.3, 129.1, 128.2, 128.0, 126.8, 115.3, 73.9, 71.1, 49.9, 39.6, 33.2, 32.9, 29.6, 27.4, 20.5, 20.3, 20.0, 19.8, 17.0; MS m/z (relative intensity, %) 433 (26.9), 277 (100), 263 (61.0), 235 (23.9), 209 (10.4), 189 (11.3), 174 (32.0), 158 (26.5), 144 (9.5), 131 (10.4), 105 (14.4). 91 (18.5), 77 (8.4), 69 (9.7); ESI-HRMS m/z calcd for $C_{28}H_{39}N_3O^+$ 433.3088, found 433.3095; FTIR (KBr, neat, cm^{-1}) ν 2973, 2929, 1615, 1515, 1466, 1383, 1264, 1134, 1080, 1036, 991, 910, 811, 766, 733, 695, 647.

*1-((1-(4-Chlorophenyl)-4,4-dimethyl-3-phenyl-4,5-dihydro-1H-pyrazol-5-yl)methoxy)-2,2,6,6-tetramethylpiperidine (**2i**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (213.1 mg, 94% yield) after flash chromatography (hexanes/EtOAc, 40:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (d, J = 7.2 Hz, 2H), 7.38−7.30 (m, 3H), 7.22−7.14 (m, 4H), 4.03−3.93 (m, 3H), 1.50 (s, 3H), 1.46 (s, 3H), 1.41−1.40 (m, 4H), 1.29−1.26 (m, 2H), 1.16 (s, 3H), 1.07 (s, 3H), 1.05 (s, 3H), 0.96 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 156.1, 143.7, 132.2, 128.5, 128.3, 128.2, 126.8, 123.9, 115.6, 73.8, 70.6, 59.65, 59.57, 49.8, 39.6, 32.9, 32.8, 29.6, 27.5, 20.2, 20.0, 19.6, 16.9; MS m/z (relative intensity, %) 455 (6.4), 453 (18.4), 299 (30.5), 297 (86.9), 285 (17.7), 283 (60.8), 255 (33.3), 194 (13.4), 158 (38.1), 156 (100), 123 (17.2), 105 (45.9), 91 (20.6), 77 (17.4), 69 (34.0); ESI-HRMS m/z calcd for $C_{27}H_{36}ClN_3O^+$ 453.2541, found 453.2550; FTIR (KBr, neat, cm^{-1}) ν 2975, 2929, 1676, 1638, 1601, 1503, 1436, 1376, 1308, 1252, 1170, 1114, 1067, 1012, 995, 914, 778, 749, 705, 693, 560.

*4-(4,4-Dimethyl-3-phenyl-5-(((2,2,6,6-tetramethylpiperidin-1-yl)oxy)methyl)-4,5-dihydro-1H-pyrazol-1-yl)benzonitrile (**2j**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (204.2 mg, 92% yield) after flash chromatography (hexanes/EtOAc, 40:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73−7.72 (m, 2H), 7.47 (d, J = 8.8 Hz, 2H), 7.42−7.38 (m, 3H), 7.21 (d, J = 8.8 Hz, 2H), 4.07−3.92 (m, 3H), 1.53 (s, 3H), 1.44 (s, 3H), 1.39−1.26 (m, 6H), 1.11 (s, 3H), 1.05 (s, 3H), 0.99 (s, 3H), 0.86 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 158.7, 147.4, 133.0, 131.5, 128.9, 128.3, 126.9, 120.3, 113.0, 99.6, 73.7, 69.7, 59.7, 59.6, 49.6, 39.5, 32.8, 32.6, 29.5, 27.8, 20.2, 19.9, 19.2, 16.8; MS m/z (relative intensity, %) 444 (12.2), 288 (100), 274 (39.8), 246 (64.7), 189 (40.7), 158 (26.0), 149 (34.2), 131 (20.6), 111 (14.3), 97 (29.4), 85 (46.9), 71 (60.7), 57 (79.8); ESI-HRMS m/z calcd for $C_{28}H_{36}N_4O^+$: 444.2884, found 444.2882; FTIR (KBr, neat, cm^{-1}) ν 2973, 2931, 2250, 2215, 1603, 1516, 1466, 1404, 1324, 1298, 1242, 1174, 1135, 1106, 1080, 1029, 992, 955, 910, 828, 767, 734, 695, 542.

*Diisopropyl 1-((1-(4-Cyanophenyl)-4,4-dimethyl-3-phenyl-4,5-dihydro-1H-pyrazol-5-yl)methyl)hydrazine-1,2-dicarboxylate (**3j**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (218.5 mg, 89% yield) after flash chromatography (hexanes/EtOAc, 3:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (d, J = 3.2 Hz, 2H), 7.49 (d, J = 8.8 Hz, 2H), 7.41 (t, J = 3.6 Hz, 3H), 7.18 (d, J = 7.6 Hz, 2H), 6.38−6.22 (brs, 1H), 4.99−4.92 (m, 2H), 4.33 (s, 1H), 3.91 (s, 1H), 3.49 (s, 1H), 1.52 (s, 3H), 1.44 (s, 3H), 1.27−1.22 (m, 12H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 159.0, 156.3, 155.7, 154.8, 147.0, 133.4, 131.3, 129.2, 128.5, 127.1, 120.1, 112.7, 100.2, 72.1, 70.5, 70.2, 69.9, 67.3, 50.3, 48.1, 47.3, 31.8, 29.6, 27.5, 22.6, 21.9, 21.85, 21.81, 21.6, 18.5, 14.0; MS m/z (relative intensity, %) 491 (9.1), 287 (2.0), 274 (100), 259 (1.7), 204 (1.8), 191 (1.9), 155 (5.3), 120 (3.8), 103 (7.4), 85 (12.2), 71 (11.6) 57 (12.7); ESI-HRMS m/z calcd for $C_{27}H_{33}N_5O_4$ + H^+ 492.2605, found 492.2613; FTIR (KBr, neat, cm^{-1}) ν 3306, 3056, 2982, 2930, 2217, 1717, 1603, 1516, 1468, 1403, 1264, 1231, 1176, 1107, 1035, 940, 917, 872, 830, 768, 736, 696, 546.

*1-((4,4-Dimethyl-3-phenyl-1-(4-(trifluoromethyl)phenyl)-4,5-dihydro-1H-pyrazol-5-yl)methoxy)-2,2,6,6-tetramethylpiperidine (**2k**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (216.7 mg, 89% yield) after flash chromatography (hexanes/EtOAc, 40:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, J = 7.2 Hz, 2H), 7.47 (d, J = 8.4 Hz, 2H), 7.40−7.34 (m, 3H), 7.26−7.23 (m, 2H), 4.06−3.95 (m, 3H), 1.53 (s, 3H), 1.46 (s, 3H), 1.40−1.26 (m, 6H), 1.16 (s, 3H), 1.06 (s, 3H), 1.02 (s, 3H), 0.92 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 157.3, 147.0, 131.9, 128.5, 128.2, 126.9, 125.9 (q, J = 4 Hz), 124.8 (q, J = 270 Hz), 119.9 (q, J = 32 Hz), 112.9, 73.7, 70.0, 59.7, 59.6, 49.7, 39.5, 32.82, 32.76, 29.5, 27.8, 20.2, 19.8, 19.5, 16.8; MS m/z (relative intensity, %) 487 (7.8), 331 (100), 317 (90.4), 289 (41.1), 228 (10.3), 189 (36.5), 156 (24.9), 149 (30.5), 105 (23.5), 77 (16.8), 69 (34.7), 55 (32.5); ESI-HRMS m/z calcd for $C_{28}H_{36}F_3N_3O^+$ 487.2805, found 487.2810; FTIR (KBr, neat, cm^{-1}) ν 2974, 2932, 1614, 1526, 1467, 1400, 1328, 1185, 1160, 1112, 1068, 991, 910, 831, 766, 734, 694.

*tert-Butyl (4,4-Dimethyl-1-phenyl-5-(((2,2,6,6-tetramethylpiperidin-1-yl)oxy)methyl)-4,5-dihydro-1H-pyrazol-3-yl)-1H-indole-1-carboxylate (**2l**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (251.1 mg, 90% yield) after flash chromatography (hexanes/EtOAc, 40:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.50 (dd, J = 2.4 Hz, J = 6.4 Hz, 1H), 8.00 (d, J = 6.0 Hz, 1H), 7.90 (s, 1H), 7.39−7.27 (m, 6H), 6.86 (td, J = 3.4 Hz, J = 6.0 Hz, 1H), 4.10−4.00 (m, 3H), 1.71 (s, 9H), 1.64 (s, 3H), 1.49 (s, 3H), 1.42−1.41 (m, 4H), 1.30−1.26 (m, 2H), 1.22 (s, 3H), 1.08 (s, 6H), 1.02 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 150.8, 149.2, 144.7, 134.6, 128.6, 128.3, 124.5, 123.1, 122.9, 122.6, 118.8, 114.2, 114.1, 112.4, 83.7, 73.3, 68.7, 59.2, 59.1, 49.9, 39.2, 39.1, 32.6, 32.4, 27.7, 27.1, 19.9, 19.8, 19.5, 16.5; MS m/z (relative intensity, %) 558 (10.3), 458 (10.7), 346 (68.3), 332 (17.4), 302 (36.9), 288 (72.0), 232 (41.6), 190 (97.3), 146 (68.5), 126 (71.5), 118 (32.7), 77 (21.5), 69 (58.4), 57 (100); ESI-HRMS m/z calcd for $C_{34}H_{46}N_4O_3^+$ 558.3564, 558.3573; FTIR (KBr, neat, cm^{-1}) ν

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2974, 2930, 1734, 1598, 1531, 1500, 1452, 1357, 1308, 1280, 1242, 1156, 1131, 1101, 1068, 1050, 1032, 932, 855, 762, 748, 693, 588.

*1-((3-(tert-Butyl)-1-phenyl-4,5-dihydro-1H-pyrazol-5-yl)-methoxy)-2,2,6,6-tetramethylpiperidine (**2m**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (126.1 mg, 68% yield) after flash chromatography (hexanes/EtOAc, 40:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20 (t, J = 8.0 Hz, 2H), 7.07 (d, J = 8.0 Hz, 2H), 6.74 (t, J = 8.0 Hz, 1H), 4.30−4.23 (m, 1H), 3.94 (dd, J = 4.8 Hz, J = 9.2 Hz, 1H), 3.74 (dd, J = 6.8 Hz, J = 9.2 Hz, 1H), 3.03 (dd, J = 10.8 Hz, J = 17.2 Hz, 1H), 2.84 (dd, J = 4.8 Hz, J = 17.2 Hz, 1H), 1.52−1.41 (m, 6H), 1.22 (s, 9H), 1.73 (s, 3H), 1.10 (s, 3H), 1.06 (s, 3H), 1.05 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 159.9, 146.2, 128.8, 118.2, 113.1, 76.4, 59.8, 58.7, 39.6, 35.8, 33.8, 33.0, 28.3, 20.2, 20.18, 17.0; MS m/z (relative intensity, %) 371 (13.5), 215 (88.2), 201 (6.8), 185 (9.5), 158 (49.0), 145 (90.1), 132 (58.9), 126 (100), 117 (9.2), 104 (24.3), 91 (11.3), 77 (30.7), 69 (15.6), 57 (37.6); ESI-HRMS m/z calcd for $C_{23}H_{37}N_3O^+$ 371.2931, found 371.2934; FTIR (KBr, neat, cm^{-1}) ν 2967, 2930, 2870, 1740, 1599, 1501, 1469, 1396, 1376, 1361, 1331, 1306, 1265, 1180, 1132, 1050, 1036, 997, 958, 926, 876, 818, 745, 692.

*1-((3-(tert-Butyl)-1-phenyl-1H-pyrazol-5-yl)methoxy)-2,2,6,6-tetramethylpiperidine (**2m′**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (12.9 mg, 7% yield) after flash chromatography (hexanes/EtOAc, 40:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, J = 8.4 Hz, 2H), 7.42 (t, J = 7.6 Hz, 2H), 7.32 (t, J = 7.4 Hz, 1H), 6.30 (s, 1H), 4.70 (s, 2H), 1.58−1.44 (m, 6H), 1.37 (s, 9H), 1.14−1.11 (m, 12H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 162.0, 139.9, 139.0, 128.8, 127.2, 124.9, 104.7, 69.6, 59.8, 39.7, 32.9, 32.0, 30.5, 30.4, 20.1, 16.9; MS m/z (relative intensity, %) 369 (0.04), 213 (100), 197 (4.2), 170 (0.9), 156 (30.6), 130 (4.4), 123 (6.2), 114 (0.8), 91 (1.0), 81 (2.9), 69 (4.8), 57 (4.7); ESI-HRMS m/z calcd for $C_{23}H_{35}N_3O^+$ 369.2775, found 369.2780; FTIR (KBr, neat, cm^{-1}) ν 3348, 3054, 3023, 2965, 2867, 1636, 1602, 1502, 1476, 1363, 1296, 1252, 1202, 1138, 1086, 1061, 994, 919, 881, 749, 693, 558, 503.

(3aS,6S*,6aS*)-3a-Methyl-1,3-diphenyl-6-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)-1,3a,4,5,6,6a-hexahydrocyclopenta[c]pyrazole (**2n**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (204.7 mg, 95% yield) after flash chromatography (hexanes/EtOAc, 40:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (d, J = 8.0 Hz, 2H), 7.47 (d, J = 7.6 Hz, 2H), 7.37−7.28 (m, 5H), 6.83 (t, J = 7.0 Hz, 1H), 4.46 (s, 2H), 2.40 (t, J = 7.6 Hz, 1H), 2.14−2.05 (m, 2H), 1.72 (s, 1H), 1.71 (s, 3H), 1.69−1.42 (m, 5H), 1.36 (s, 1H), 1.28 (s, 3H), 1.17 (s, 9H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 152.2, 144.5, 131.8, 128.9, 128.4, 127.9, 126.3, 118.6, 113.1, 88.7, 77.5, 60.3, 59.8, 58.4, 40.5, 40.4, 36.8, 35.5, 34.3, 31.4, 29.7, 25.4, 20.4, 17.2; MS m/z (relative intensity, %) 431 (11.6), 289 (11.0), 275 (100), 269 (14.1), 247 (14.8), 241 (11.7), 195 (9.3), 172 (38.2), 157 (7.0), 130 (11.5), 105 (6.5), 92 (11.7), 77 (15.7); ESI-HRMS m/z calcd for $C_{28}H_{37}N_3O^+$ 431.2931, found 431.2933; FTIR (KBr, neat, cm^{-1}) ν 2966, 2931, 1716, 1669, 1598, 1544, 1497, 1455, 1386, 1336, 1294, 1256, 1149, 1134, 1038, 992, 959, 911, 767, 732, 694, 644, 497.

(3aS,7S*,7aS*)-3a-Methyl-1,3-diphenyl-7-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)-3a,4,5,6,7,7a-hexahydro-1H-indazole (**2o**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (213.6 mg, 96% yield) after flash chromatography (hexanes/EtOAc, 40:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (d, J = 6.8 Hz, 2H), 7.38−7.28 (m, 5H), 7.26−7.24 (m, 2H), 6.84 (t, J = 7.0 Hz, 1H), 4.09−4.05 (m, 1H), 4.00−3.99 (d, J = 4.8 Hz, 1H), 2.24−2.19 (m, 1H), 1.95−1.89 (m, 1H), 1.85−1.78 (m, 1H), 1.70−1.50 (m, 3H), 1.46−1.45 (m, 4H), 1.42 (s, 3H), 1.30−1.26 (m, 2H), 1.14 (s, 3H), 1.10−1.08 (m, 6H), 0.86 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 155.5, 145.5, 132.9, 128.7, 128.3, 128.1, 126.5, 119.4, 115.2, 79.7, 71.2, 60.0, 59.5, 51.1, 40.4, 34.8, 34.4, 30.3, 26.4, 25.0, 20.6, 20.2, 18.3, 17.2; MS m/z (relative intensity, %) 445 (8.9), 305 (8.4), 289 (100), 247 (15.5), 235 (7.6), 195 (10.4), 186 (18.9), 149 (11.5), 142 (13.3), 130 (9.2), 105 (15.2), 95 (16.0), 77 (19.0), 69 (12.2), 55 (16.2); ESI-HRMS m/z calcd for $C_{29}H_{39}N_3O^+$ 445.3088, found 445.3095; FTIR (KBr, neat, cm^{-1}) ν 2932, 2869, 1597, 1500, 1454, 1391, 1318, 1270, 1130, 1098, 1071, 1033, 1008, 990, 976, 910, 879, 849, 765, 734, 694.

Diisopropyl 1-((3aS,7S*,7aS*)-3a-Methyl-1,3-diphenyl-3a,4,5,6,7,7a-hexahydro-1H-indazol-7-yl)hydrazine-1,2-dicarboxylate (**3o**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (218.9 mg, 89% yield) after flash chromatography (hexanes/EtOAc, 3:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69 (d, J = 6.8 Hz, 2H), 7.40−7.32 (m, 3H), 7.24 (t, J = 6.4 Hz, 4H), 6.83 (t, J = 6.8 Hz, 1H), 5.75−5.56 (br, 1H), 4.99−4.66 (m, 2H), 4.40−3.80 (m, 2H), 2.41 (d, J = 14.4 Hz, 1H), 1.97 (s, 1H), 1.64 (d, J = 13.6 Hz, 1H), 1.52 (d, J = 13.6 Hz, 1H), 1.39 (s, 3H), 1.26−1.00 (m, 14H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 155.4, 154.0, 145.6, 132.5, 129.1, 128.4, 128.3, 126.6, 119.8, 115.2, 69.7, 69.4, 52.4, 31.1, 29.6, 27.3, 25.7, 21.9, 21.8, 21.6; MS m/z (relative intensity, %) 492 (100), 390 (8.8), 342 (6.5), 304 (11.8), 288 (59.8), 273 (19.2), 261 (15.4), 247 (10.0), 235 (41.6), 220 (7.4), 144 (5.4), 130 (7.8), 114 (8.7), 91 (6.7), 77 (8.5), 70 (10.5), 57 (5.4); ESI-HRMS m/z calcd for $C_{28}H_{36}N_4O_4$ + H^+ 493.2809, found 493.2815; FTIR (KBr, neat, cm^{-1}) ν 3356, 3307, 2980, 2937, 2865, 1755, 1712, 1596, 1497, 1468, 1384, 1305, 1270, 1229, 1181, 1108, 1031, 913, 764, 750, 733, 696.

(1,1′-(((R)-1-((R*)-4,4-Dimethyl-1,3-diphenyl-4,5-dihydro-1H-pyrazol-5-yl)ethane-1,2-diyl)bis(oxy))bis(2,2,6,6-tetramethylpiperidine)) (**2p**).* The title compound was prepared according to the general procedure and isolated as a colorless solid (220.5 mg, 75% yield) after flash chromatography (hexanes/EtOAc, 100:1) mp 146−147 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 (d, J = 7.2 Hz, 2H), 7.37−7.21 (m, 7H), 6.74 (t, J = 6.8 Hz, 1H), 4.62 (dd, J = 4.0 Hz, J = 10.8 Hz, 1H), 4.29 (d, J = 7.6 Hz, 2H), 3.99 (t, J = 9.4 Hz, 1H), 1.74 (s, 3H), 1.61−1.49 (m, 6H), 1.46 (s, 3H), 1.34 (s, 4H), 1.22 (s, 14H), 1.09 (s, 3H), 1.00 (s, 3H), 0.82 (s, 3H), 0.78 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 155.7, 144.1, 132.9, 129.0, 128.1, 127.9, 127.1, 117.7, 112.6, 79.2, 74.6, 70.6, 60.7, 59.8, 59.1, 49.5, 41.1, 40.8, 39.6, 34.2, 33.8, 33.5, 32.9, 30.2, 26.9, 20.4, 20.3, 20.0, 17.1, 17.0; MS m/z (relative intensity, %) 588 (5.2), 432 (5.1), 275 (12.4), 249 (100), 234 (2.5), 156 (8.0), 140 (8.3), 126 (7.4), 105 (4.3), 77 (5.0); ESI-HRMS m/z calcd for $C_{37}H_{56}N_4O_2^+$ 588.4398, found 588.4407; FTIR (KBr, neat, cm^{-1}) ν 2971, 2929, 2870, 1597, 1545, 1502, 1468, 1390, 1361, 1313, 1267, 1208, 1181, 1133, 1072, 1034, 1007, 990, 924, 877, 851, 820, 786, 747, 744, 718, 693, 508.

Tetraisopropyl 1,1′-((S)-1-((R*)-4,4-Dimethyl-1,3-diphenyl-4,5-dihydro-1H-pyrazol-5-yl)ethane-1,2-diyl)bis(hydrazine-1,2-dicarboxylate) (**3p**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (238.7 mg, 70% yield) after flash chromatography (hexanes/EtOAc, 3:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.74 (d, J = 8.0 Hz, 2H), 7.42−7.36 (m, 2H), 7.26 (s, 3H), 7.09 (d, J = 8.0 Hz, 2H), 6.80 (d, J = 6.4 Hz, 1H), 6.61−6.50 (br, 1H), 5.03−4.73 (m, 6H), 4.23−4.03 (m, 2H), 3.15 (d, J = 13.6 Hz, 1H), 1.68 (s, 3H), 1.36−1.33 (m, 10H), 1.26−1.18 (m, 17H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 158.7, 157.0, 156.8, 156.6, 154.9, 145.7, 132.2, 129.2, 128.9, 128.6, 128.5, 128.44, 128.37, 128.3, 127.7, 127.6, 127.3, 127.2, 118.8, 112.5, 70.73, 70.69, 69.8, 69.5, 67.5, 52.9, 52.1, 47.9, 29.6, 28.3, 22.0, 21.9, 21.8, 21.7, 17.4; MS m/z (relative intensity, %) 682 (2.1), 347 (0.4), 334 (0.6), 275 (0.9), 263 (3.6), 249 (100), 193 (0.6), 144 (0.9), 131 (1.8), 104 (2.0), 77 (1.7), 57 (2.1); ESI-HRMS m/z calcd for $C_{35}H_{50}N_6O$ + H^+ 683.3763, found 683.3772; FTIR (KBr, neat, cm^{-1}) ν 3360, 2975, 2928, 2889, 1704, 1598, 1496, 1454, 1419, 1382, 1316, 1274, 1221, 1181, 1089, 1049, 881, 766, 746, 695.

1,1′-(((R)-2-((4S*,5R*)-4-Allyl-4-methyl-1,3-diphenyl-4,5-dihydro-1H-pyrazol-5-yl)ethane-1,2-diyl)bis(oxy))bis(2,2,6,6-tetramethylpiperidine) (**2q**).* The title compound was prepared according to the general procedure and isolated as a colorless solid (147.4 mg, 48% yield) after flash chromatography (hexanes/EtOAc, 40:1) mp 149−151 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, J = 7.6 Hz, 2H), 7.38−7.29 (m, 3H), 7.24−7.22 (m, 4H), 6.73 (td, J = 4.0 Hz, J = 8.0 Hz, 1H), 5.72 (ddd, J = 7.2 Hz, J = 16.8 Hz, J = 24.4 Hz, 1H), 5.11−5.02 (m, 2H), 4.61 (d, J = 8.0 Hz, 1H), 4.44 (s, 1H), 4.24 (dd, J = 4.0 Hz, J = 8.0 Hz, 1H), 3.96 (s, 1H), 2.48−2.37 (m, 2H), 1.74 (s, 3H), 1.60−1.49 (m, 6H), 1.43 (s, 4H), 1.34 (s, 4H), 1.34−1.21 (m, 10H), 1.08 (s, 3H), 1.00 (s, 3H), 0.82 (s, 3H), 0.75 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 153.9, 143.6, 133.4, 133.0, 129.0, 128.2, 127.8, 127.2, 118.9, 117.6, 112.6, 79.5, 74.7, 66.2, 60.7, 59.8, 59.0, 53.2, 45.9, 41.1, 40.7, 39.6, 34.2, 33.5, 32.8, 29.7, 20.5, 20.4, 20.3, 20.0, 18.6, 17.1, 17.0; MS m/z (relative intensity, %) 614 (1.9), 458 (2.2), 302 (16.4), 275 (33.3), 261 (100), 233 (8.6), 221 (8.3), 156 (9.4), 105 (10.7), 91 (6.0), 77 (14.6), 57 (10.0); ESI-HRMS m/z calcd for $C_{39}H_{58}N_4O_2^+$ 614.4554, found 614.4562; FTIR (KBr, neat,

cm^{-1}) ν 3058, 2926, 2870, 2852, 1742, 1638, 1597, 1543, 1502, 1465, 1378, 1361, 1316, 1263, 1208, 1180, 1133, 1073, 1031, 991, 956, 915, 877, 851, 764, 743, 714, 693, 605, 506.

(3aR,5R*,6R*,6aS*)-3a-Methyl-1,3-diphenyl-5,6-bis(((2,2,6,6-tetramethylpiperidin-1-yl)oxy)methyl)-1,3a,4,5,6,6a-hexahydrocyclopenta[c]pyrazole (**4q**).* The title compound was prepared according to the general procedure and isolated as a colorless solid (18.4 mg, 15% yield) after flash chromatography (hexanes/EtOAc, 40:1) mp 155−157 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91 (d, J = 7.2 Hz, 2H), 7.54 (d, J = 8.0 Hz, 2H), 7.38 (t, J = 7.6 Hz, 2H), 7.32−7.28 (m, 3H), 6.84 (t, J = 7.2 Hz, 1H), 4.51 (s, 1H), 4.00 (dd, J = 4.2 Hz, J = 8.6 Hz, 1H), 3.83 (dd, J = 8.8 Hz, J = 12.0 Hz, 1H), 3.75 (t, J = 8.0 Hz, 1H), 3.65 (t, J = 8.0 Hz, 1H), 2.72−2.64 (m, 2H), 2.39−2.32 (m, 1H), 1.74 (t, J = 13.2 Hz, 1H), 1.69 (s, 3H), 1.52−1.50 (m, 6H), 1.40−1.38 (m, 6H), 1.31 (s, 3H), 1.26−1.24 (m, 9H), 1.10 (s, 3H), 1.07 (s, 3H), 1.01 (s, 3H), 0.99 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 151.4, 144.3, 131.8, 129.0, 128.4, 127.8, 126.3, 118.4, 112.8, 76.2, 76.0, 74.1, 60.0, 59.7, 59.6, 58.0, 46.4, 41.3, 40.6, 39.7, 39.64, 39.57, 39.5, 33.5, 33.4, 33.3, 33.1, 29.7, 27.6, 20.8, 20.2, 20.04, 19.99, 17.1, 17.0; MS m/z (relative intensity, %) 614 (6.4), 458 (6.2), 303 (13.6), 275 (100), 261 (56.6), 247 (8.3), 233 (17.4), 221 (15.6), 156 (15.3), 149 (16.9), 140 (18.5), 105 (15.8), 85 (18.3), 71 (21.3), 69 (22.0), 57 (25.9); ESI-HRMS m/z calcd for $C_{39}H_{58}N_4O_2^+$ 614.4554, found 614.4559; FTIR (KBr, neat, cm^{-1}) ν 3058, 2928, 2871, 1739, 1598, 1545, 1502, 1457, 1378, 1359, 1292, 1263, 1245, 1211, 1182, 1163, 1134, 1076, 1040, 992, 956, 931, 882, 794, 765, 744, 695, 639, 557, 489.

(3aR,5R*,6R*,6aS*)-3a-Allyl-1,3-diphenyl-5,6-bis(((2,2,6,6-tetramethylpiperidin-1-yl)oxy)methyl)-1,3a,4,5,6,6a-hexahydrocyclopenta[c]pyrazole (**4r**).* The title compound was prepared according to the general procedure and isolated as a colorless solid (57.6 mg, 45% yield) after flash chromatography (hexanes/EtOAc, 40:1) mp 158−159 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, J = 7.6 Hz, 2H), 7.51 (d, J = 8.0 Hz, 2H), 7.37 (t, J = 7.6 Hz, 1H), 7.28 (t, J = 8.0 Hz, 3H), 6.82 (t, J = 7.2 Hz, 1H), 5.51 (ddd, J = 8.8 Hz, J = 32.8 Hz, J = 25.2 Hz, 1H), 5.03−4.92 (m, 2H), 4.66 (s, 1H), 3.96 (dd, J = 4.4 Hz, J = 8.8 Hz, 1H), 3.82−3.73 (m, 2H), 3.66 (t, J = 8.2 Hz, 1H), 3.15 (dd, J = 5.6 Hz, J = 14.4 Hz, 1H), 2.71−2.63 (m, 2H), 2.40−2.32 (m, 2H), 1.77 (t, J = 13.2 Hz, 1H), 1.63−1.57 (m, 2H), 1.51 (s, 5H), 1.40−1.38 (m, 5H), 1.31 (s, 3H), 1.29 (s, 3H), 1.25 (s, 3H), 1.23 (s, 3H), 1.09 (s, 3H), 1.08 (s, 3H), 1.02 (s, 3H), 0.99 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 149.1, 143.8, 134.1, 132.2, 128.9, 128.4, 127.8, 126.0, 118.3, 112.9, 76.1, 74.3, 71.8, 62.5, 60.0, 59.7, 59.6, 46.2, 43.4, 40.2, 40.1, 39.8, 39.7, 39.6, 33.7, 33.3, 33.1, 20.7, 20.3, 20.05, 19.99, 17.1, 17.0; MS m/z (relative intensity, %) 640 (6.2), 484 (4.7), 378 (5.8), 364 (16.9), 318 (10.5), 305 (21.9), 291 (12.1), 235 (100), 219 (12.8), 191 (26.3), 140 (31.2), 77(4.1); ESI-HRMS m/z calcd for $C_{41}H_{60}N_4O_2^+$ 640.4711, found 640.4717; FTIR (KBr, neat, cm^{-1}) ν 3059, 2927, 1742, 1641, 1598, 1544, 1503, 1458, 1377, 1358, 1301, 1246, 1182, 1135, 1074, 1033, 992, 955, 920, 767, 746, 694, 495.

*5,5-Dimethyl-1,3-diphenyl-6-(((2,2,6,6-tetramethylpiperidin-1-yl)oxy)methyl)-1,4,5,6-tetrahydropyridazine (**2s**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (201.3 mg, 93% yield) after flash chromatography (hexanes/EtOAc, 20:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 (d, J = 7.2 Hz, 2H), 7.46 (d, J = 8.0 Hz, 2H), 7.38−7.34 (m, 2H), 7.30−7.24 (m, 3H), 6.85 (ddd, J = 0.8 Hz, J = 7.2 Hz, J = 8.0 Hz, 1H), 4.01 (dd, J = 6.6 Hz, J = 11.6 Hz, 1H), 3.88 (dd, J = 6.4 Hz, J = 11.2 Hz, 2H), 2.49 (d, J = 17.2 Hz, 1H), 2.37 (d, J = 17.6 Hz, 1H), 1.46−1.31 (m, 6H), 1.26 (s, 3H), 1.06 (s, 3H), 0.98 (s, 3H), 0.96 (s, 3H), 0.92 (s, 3H), 0.81 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 147.7, 139.2, 138.5, 128.6, 128.1, 127.3, 124.6, 119.2, 114.3, 74.7, 60.1, 59.8, 39.6, 34.5, 32.8, 29.7, 29.2, 28.5, 27.32, 27.27, 20.25, 20.15, 17.0; MS m/z (relative intensity, %) 433 (17.9), 277 (100), 263 (18.1), 247 (6.0), 221 (50.8), 207 (23.4), 171 (3.1), 158 (16.6), 144 (3.5), 118 (2.7), 104 (8.0), 77 (8.5), 69 (10.1); ESI-HRMS m/z calcd for $C_{28}H_{39}N_3O^+$ 433.3088, found 433.3091; FTIR (KBr, neat, cm^{-1}) ν 2970, 2929, 1595, 1564, 1494, 1469, 1446, 1394, 1342, 1260, 1165, 1132, 1044, 991, 909, 747, 691.

*Diisopropyl 1-((4,4-Dimethyl-2,6-diphenyl-2,3,4,5-tetrahydropyridazin-3-yl)methyl)hydrazine-1,2-dicarboxylate (**3s**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (192.0 mg, 80% yield) after flash chromatography (hexanes/EtOAc, 3:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (d, J = 7.2 Hz, 2H), 7.41−7.36 (m, 4H), 7.30−7.24 (m, 3H), 6.87 (t, J = 7.2 Hz, 1H), 5.98−5.71 (brs, 1H), 4.83−4.80 (m, 2H), 4.29−4.11 (m, 2H), 3.79−3.16 (m, 1H), 3.42 (t, J = 22.4 Hz, 2H), 1.24 (s, 3H), 1.16−1.10 (m, 12H), 0.97 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 156.0, 155.4, 155.2, 147.6, 139.6, 138.9, 138.6, 129.2, 128.2, 127.8, 124.7, 124.6, 120.1, 119.7, 113.7, 70.6, 70.0, 69.8, 69.6, 58.6, 58.0, 48.9, 33.6, 29.6, 29.3, 28.1, 26.7, 21.9, 21.8; MS m/z (relative intensity, %) 480 (10.2), 279 (1.5), 263 (100), 247 (6.7), 221 (2.8), 192 (3.3), 171 (3.7), 149 (6.3), 131 (3.8), 105 (9.7), 91 (16.8), 71 (11.7), 57 (12.5); ESI-HRMS m/z calcd for $C_{27}H_{36}N_4O + H^+$ 481.2809, found 481.2803; FTIR (KBr, neat, cm^{-1}) ν 3376, 2978, 2927, 1711, 1598, 1556, 1493, 1467, 1409, 1378, 1341, 1284, 1232, 1179, 1152, 1107, 1046, 1000, 967, 938, 916, 881, 838, 752, 693.

*5-Methyl-1,3,5-triphenyl-6-(((2,2,6,6-tetramethylpiperidin-1-yl)oxy)methyl)-1,4,5,6-tetrahydropyridazine (**2t**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (108.9 mg, 44% yield) after flash chromatography (hexanes/EtOAc, 40:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 (d, J = 7.6 Hz, 2H), 7.60 (d, J = 8.0 Hz, 2H), 7.48 (d, J = 7.6 Hz, 2H), 7.43−7.38 (m, 4H), 7.35−7.31 (m, 3H), 7.26 (d, J = 7.2 Hz, 1H), 6.90 (t, J = 7.2 Hz, 1H), 4.54 (d, J = 7.6 Hz, 1H), 3.72−3.67 (m, 1H), 3.53−3.48 (m, 1H), 3.04 (d, J = 17.2 Hz, 1H), 2.81 (d, J = 17.2 Hz, 1H), 1.42−1.23 (m, 6H), 1.20 (s, 3H), 0.94 (s, 3H), 0.74 (s, 6H), 0.64 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 148.0, 145.7, 139.2, 138.3, 128.8, 128.7, 128.3, 127.5, 126.7, 125.1, 124.7, 119.7, 115.0, 75.3, 60.4, 59.8, 59.5, 39.6, 39.5, 36.3, 32.3, 32.2, 31.0, 29.1, 20.2, 20.0, 16.9; MS m/z (relative intensity, %) 495 (9.1), 433 (4.6), 339 (80.6), 325 (21.4), 277 (33.0), 249 (7.9), 221 (30.3), 207 (90.5), 193 (12.2), 179 (15.8), 131 (59.6), 105 (100), 91 (46.7), 71 (43.4), 57 (55.8); ESI-HRMS m/z calcd for $C_{33}H_{41}N_3O^+$ 495.3244, found 495.3242; FTIR (KBr, neat, cm^{-1}) ν 3060, 3028, 2971, 2929, 1732, 1694, 1596, 1564, 1495, 1470, 1447, 1375, 1341, 1262, 1168, 1133, 1076, 1045, 993, 909, 749, 695.

*5-Methyl-1,3,5-triphenyl-6-(((2,2,6,6-tetramethylpiperidin-1-yl)oxy)methyl)-1,4,5,6-tetrahydropyridazine (**2t'**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (108.9 mg, 44% yield) after flash chromatography (hexanes/EtOAc, 40:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88 (d, J = 7.2 Hz, 2H), 7.40 (t, J = 7.6 Hz, 2H), 7.30 (t, J = 7.2 Hz, 1H), 7.25−7.22 (m, 4H), 7.20−7.13 (m, 4H), 7.06 (t, J = 7.0 Hz, 1H), 6.75 (t, J = 7.2 Hz, 1H), 4.56 (d, J = 2.0 Hz, 1H), 4.14 (dd, J = 3.4 Hz, J = 9.4 Hz, 1H), 4.04 (dd, J = 6.6 Hz, J = 9.4 Hz, 1H), 3.24 (d, J = 18.0 Hz, 1H), 2.71 (d, J = 18.0 Hz, 1H), 1.57 (s, 3H), 1.38−1.20 (m, 6H), 1.11 (s, 3H), 0.99 (s, 6H), 0.82 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 147.3, 146.3, 138.6, 138.5, 128.4, 128.2, 127.5, 126.4, 124.8, 124.6, 119.4, 114.7, 74.7, 60.7, 59.8, 39.6, 36.9, 32.9, 32.8, 32.3, 28.5, 20.3, 20.1, 17.0; MS m/z (relative intensity, %) 495 (13.9), 339 (100), 325 (27.2), 275 (6.0), 249 (19.6), 234 (10.9), 221 (41.1), 207 (12.5), 131 (6.5), 105 (17.2), 91 (14.0), 85 (19.4), 71 (22.3), 57 (26.3); ESI-HRMS m/z calcd for $C_{33}H_{41}N_3O^+$ 495.3244, found 495.3251; FTIR (KBr, neat, cm^{-1}) ν 3060, 3029, 2971, 2930, 1944, 1871, 1799, 1734, 1596, 1565, 1495, 1447, 1374, 1342, 1304, 1263, 1171, 1075, 1044, 993, 977, 955, 924, 908, 856, 814, 760, 746, 693, 571, 547, 529, 507.

*3,5,5-Trimethyl-1-(4-nitrophenyl)-6-(((2,2,6,6-tetramethylpiperidin-1-yl)oxy)methyl)-1,4,5,6-tetrahydropyridazine (**2u**).* The title compound was prepared according to the general procedure and isolated as a yellow oil (124.8 mg, 60% yield) after flash chromatography (hexanes/EtOAc, 10:1) ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.12 (d, J = 8.8 Hz, 2H), 7.32 (d, J = 6.8 Hz, 2H), 3.98 (d, J = 8.4 Hz, 1H), 3.86−3.77 (m, 2H), 2.18 (d, J = 18.0 Hz, 1H), 2.04 (s, 3H), 1.86 (d, J = 18.4 Hz, 1H), 1.39−1.26 (m, 6H), 1.15 (s, 3H), 1.06 (s, 3H), 1.01 (s, 3H), 0.96 (s, 3H), 0.87 (s, 3H), 0.74 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 151.0, 145.9, 137.0, 123.9, 110.5, 72.4, 58.3, 57.7, 38.05, 38.00, 37.0, 31.2, 31.0, 28.1, 27.8, 26.6, 25.3, 22.6, 18.7, 18.6, 15.4; MS m/z (relative intensity, %) 416 (3.5), 260 (100), 246 (12.1), 214 (21.3), 204 (13.0), 158 (3.6), 149 (3.2), 122 (3.3), 69 (21.6), 55 (6.6), 42 (8.8); ESI-HRMS m/z calcd for $C_{23}H_{36}N_4O_3^+$ 416.2782, found 416.2787; FTIR (KBr, neat, cm^{-1}) ν 2956, 2926, 1736, 1593, 1502, 1467, 1375, 1315, 1257, 1232, 1171, 1133, 1112, 1086, 1029, 978, 837, 791, 752, 692.

■ ASSOCIATED CONTENT

Supporting Information

Figures, tables, and CIF files giving ^{1}H NMR and ^{13}C NMR spectra for new substrates and all products, X-ray crystallographic data and ORTEP plots for the compounds **2p**, **2q**, and **4q**, and computational data. 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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