Preparation of Substituted 1,2-Dihydro-3*H*-pyrazol-3-ones from Polylithiated 2'-Phenylphenylacetohydrazides and Aromatic Esters

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Dedicated to the Memory of Raymond N. Castle

Several 2'-phenylphenylacetohydrazides were polylithiated with excess lithium diisopropylamide, and the resulting intermediates were condensed with several aromatic esters to afford *C*-acylated intermediates that were not usually isolated, but acid cyclized directly to 1,4,5-trisubstituted, 1,2-dihydro-3*H*-pyrazol-3-ones.

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While the preparations, reactions, and uses of 1*H*-pyrazoles and related heterocyclic compounds are well documented [1], investigations involving other pyrazole compounds such as 1,2-dihydro-3*H*-pyrazol-3-ones [2,3] have received less investigative attention. For example, a key compound to this report, 1,2-dihydro-1,4,5-triphenyl-3*H*-pyrazol-3-one **4**, has been prepared by: (1) the fusion of 2'-phenylacetohydrazine with ethyl 2-benzoyl-2-phenylacetate [4]; or (2) by the condensation of benzoylphenyl ketene with phenylhydrazine [5]; or (3) by the reaction of diphenylcyclopropenone with excess phenylhydrazine [6]. Several additional and related alkyl, or alkyl-aryl, 1,4,5-trisubstituted, 1,2-dihydro-3*H*-pyrazol-3-ones have also been prepared and studied, especially with regard to their biological-health applications or use in other syntheses [7-15]. There is a preference to listing the structures for these molecules as 1,2-dihydro-3*H*-pyrazol-3-ones instead of their tautomers, 3-hydroxy-1*H*-pyrazoles. Both forms have been reported by investigators [4-19], which may indicate the differences that exist when the supporting structural data was obtained from a solution, a mull, or a crystalline form of a particular compound.

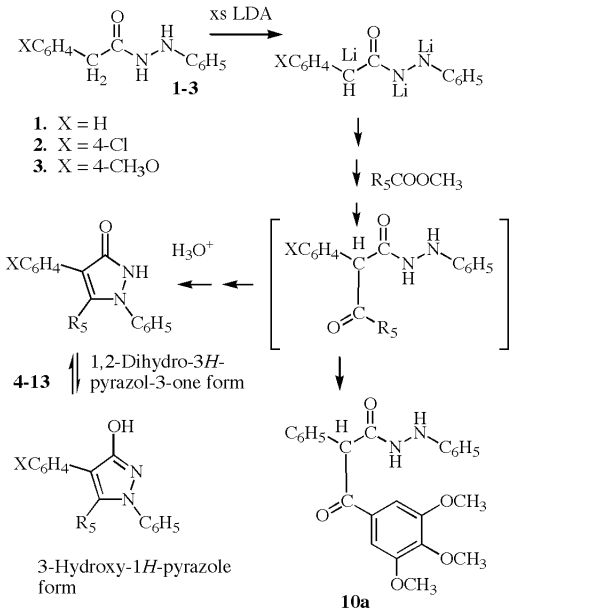
Compound **1**, 2'-phenylphenylacetohydrazide, a key starting material used during this study, has been used for the preparation of other pyrazole or pyrazole-related heterocyclic compounds such as methods involving variously substituted *N*-methyl or *N*-acylphenylacetohydrazides, or a condensation-cyclization of a probable carbanion resulting from deprotonation with calcium hydride followed by the addition of *N*,*N*-dimethylformamide [20-25].

In recent investigations with other carbohydrazides, we polylithiated *o*-toluoylcarboalkoxyhydrazides (2'-(2-methylbenzoyl)hydrazinocarboxylic acid esters) with excess lithium diisopropylamide, and condensed-cyclized the polylithiated intermediates with a variety of aromatic esters. This was followed by acid cyclization of the *C*-acylated intermediates to afford isocarbostyrils (1(2*H*)-isoquinolinones) [26].

One of our major strong-base multiple anion synthesis efforts has dealt with the preparation of 1*H*-pyrazoles and related compounds by the utilization of C(α), *N*-hydrazone (*e.g.*, phenyl, benzoyl, carboalkoxy, *etc*.) entry compounds that were polylithiated with excess lithium diisopropylamide [27-41]. The polylithiated intermediates were condensed with a variety of esters and other electrophilic reagents, followed by an acid cyclization of *C*-acylated intermediates that were not usually isolated. This resulted in an unequivocal synthesis of a single pyrazole isomer, especially unsymmetrical 3,5-disubstituted, in good yields, that could be easily purified by recrystallization from common solvents.

The focus of this introductory study has been to polylithiate several 2'-phenylphenylacetohydrazides **1**-**3** with excess lithium diisopropylamide, *C*-acylate the polylithated intermediates (presumed trilithiation, see Scheme) [42] with a variety of benzoate esters, followed by acid cyclization to the targeted dihydropyrazolones **4**-**13**. Initially, polylithiated phenylhydrazide **1** was condensed-cyclized with methyl benzoate to afford dihydropyrazolone **4** in an 83% yield (mp 283-285°; lit mp 282° [6]). The yield of other compounds prepared, **5**-**13**, ranged from 52-97%, and they were characterized by ^{1}H and ^{13}C nuclear magnetic resonance spectra, with support from combustion analysis for C, H, and N. It was possible to isolate a *C*-acylated product, as evidenced from the condensation of polylithiated acid hydrazide (from **1**) with methyl 3,4,5-trimethoxybenzoate to afford β-ketohydrazide **10a** in a 76 % yield.

Scheme Preparation of 1,2-Dihydro-3*H*-pyrazol-3-ones **4-13** from 2'-Phenylphenylacetohydrazides **1-3**.



4. X = H; R_5 = C_6H_5
5. X = H; R_5 = 4-$CH_3OC_6H_4$
6. X = H; R_5 = 4-ClC_6H_4
7. X = H; R_5 = 4-$CH_3C_6H_4$
8. X = H; R_5 = 2-HOC_6H_4
9. X = H; R_5 = 2-HO, 3-$CH_3OC_6H_3$
10. X = H; R_5 = 3,4,5-$(CH_3O)_3C_6H_2$
11. X = H; R_5 = 4-$(CH_3)_3CC_6H_4$
12. X = 4-CH_3O; R_5 = 4-$CH_3OC_6H_4$
13. X = 4-Cl; R_5 = C_6H_5

Since infrared spectra of compounds **4-13** did not give consistent or convincing carbonyl or hydroxyl absorptions [43], and ^{1}H nmr spectra of compounds **4** and **6** did not display NH/OH absorptions, an X-ray crystal structure of dihydropyrazolone **8** (X = H and R_5 = 2-hydroxyphenyl) [44] was obtained. Surprisingly, good crystals for this analysis were obtained from *tert*-butyl alcohol, and the overall structure was found in the 3-hydroxy-1*H*-pyrazole form.

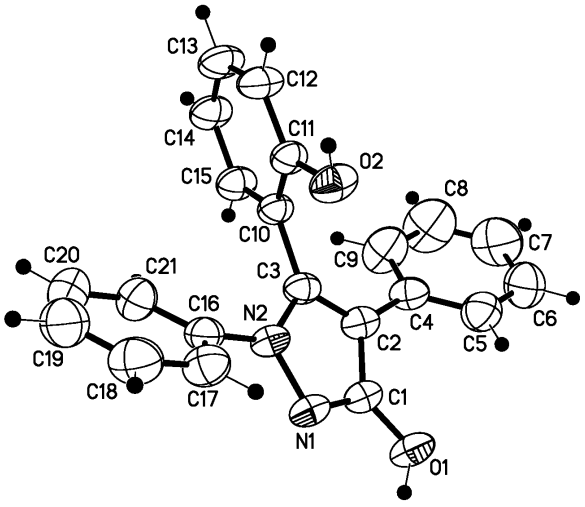


Figure 1. ORTEP diagram (50% ellipsoids for non-hydrogen atoms) for **8**, $C_{21}H_{16}N_2O_2$.

The molecular structure of **8**, $C_{21}H_{16}N_2O_2$ (unsolvated) is shown in Figure 1, atomic positional parameters are listed in Table 2, and selected bond distances and angles are listed in Table 3.

Each of the rings is essentially planar with a mean deviation from each respective least squares best plane of 0.0045 Å for the heterocylic ring, 0.0075 Å for C4-C9, 0.0057 Å for C10-C15, and 0.0054 Å for C16-C21. The least squares best planes representing the three phenyl groups are somewhat perpendicular to the heterocylic ring with angles of 141.30° for C4-C9, 108.15° for C10-C15, and 135.44° for C16-C21.

The crystal packing is dominated by hydrogen bonding. Molecules related by inversion symmetry (at ($^1/_2$, 0, 1)) are linked into dimers through O-H···N interactions involving the pyrazole nitrogen atom and the exocyclic hydroxyl group (O1···N1' 2.747(3) Å; H1···N1' 1.83 Å; O1-H1···N1' 175°). Dimers related by inversion symmetry (at (0, 0, $^1/_2$)) are linked together through bridges involving *t*-butyl alcohol solvent molecules, involving the hydroxyl groups of the solvent and of the phenol ring of the molecule. The bridging interactions are asymmetric, with one pair of short interactions (O2···O3" 2.685(3) Å; H2···O3" 1.76 Å; O2-H2···O3" 168°) and one pair of long interactions (O3···O2 2.985(3) Å; H26···O2 2.08 Å; O3-H26···O2 152°). The two sets of hydrogen bonding interactions result in the molecules being linked into infinite chains running parallel to the *ac*-diagonal of the unit cell (see Figure 2). There are no significant interchain interactions involved in the packing of the chains to complete the structure (see Figure 3).

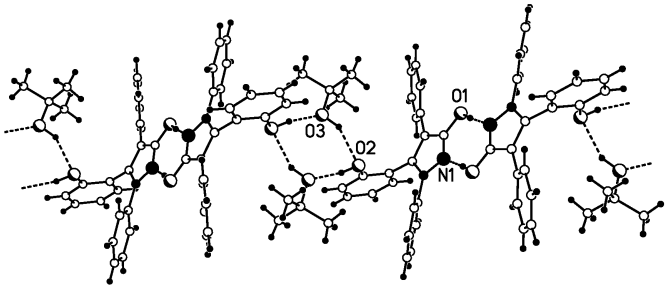


Figure 2. Chain formation resulting from *H*-bonding between Pyrazole, *N*- and exocyclic hydroxyl group and between phenol hydroxyl groups of bridging *tert*-butyl alcohol molecules.

The ^{1}H nuclear magnetic resonance spectra of **4-13** were satisfactory for identifying aromatic protons, and those associated with a functional group such as $ArOCH_3$ in **5, 9, 10** and **12**, δ 3.46-3.86 ppm; the $ArCH_3$ in **7,** δ 2.27 ppm, or the *tert*-butyl-Ar in **11**, δ 1.24 ppm. The ^{13}C nuclear magnetic resonance absorptions for the aromatic carbons and functional group carbons were routine, and some of the heterocyclic ring carbons were identified as follows:

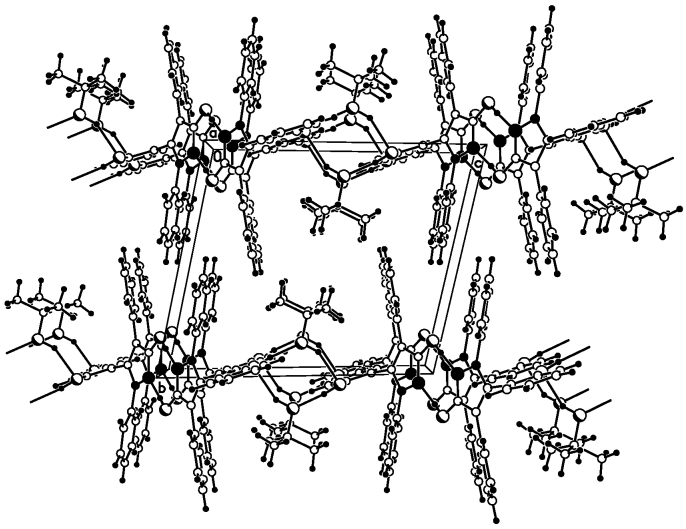


Figure 3. Packing of infinite chains.

Table 1

Crystallographic Data for **8**, $C_{21}H_{16}N_2O_2 \cdot C_4H_{10}O$

Crystal Dimensions (mm)	0.30 x 0.30 x 0.30
Space Group	P-1 (#2)
a (Å)	7.143(3)
b (Å)	12.078(7)
c (Å)	14.220(5)
α	99.06(2)°
β	103.13(1)°
γ	101.68(2)°
V (Å^3)	1143.2(9)
fw	402.49
Z	2
d_{calc} (g/cm^3)	1.17
λ(Å)	0.71069
μ (cm^{-1})	0.77
R [a]	0.062
R_w [b]	0.069
Goodness of Fit	1.86

[a] $R = \Sigma(|F_o| - |F_c|)/\Sigma |F_o|$, [b] $R_w = \{\Sigma[w(|F_o| - |F_c|)^2]/\Sigma(w|F_o|^2)\}^{1/2}$

Table 2

Atomic Positional Parameters for **8**, $C_{21}H_{16}N_2O_2 \cdot C_4H_{10}O$

atom	*x*	*y*	*z*	*B*eq
O(1)	0.3329(2)	-0.1560(1)	0.9569(1)	4.22(4)
O(2)	-0.0026(2)	0.0412(2)	0.6627(1)	4.15(4)
O(3)	-0.0329(3)	-0.1430(2)	0.4893(1)	5.61(5)
N(1)	0.2908(2)	0.0276(2)	0.9424(1)	3.37(4)
N(2)	0.1371(2)	0.0684(2)	0.8921(1)	3.23(4)
C(1)	0.2224(3)	-0.0856(2)	0.9214(2)	3.22(5)
C(2)	0.0248(3)	-0.1227(2)	0.8589(2)	3.33(5)
C(3)	-0.0229(3)	-0.0212(2)	0.8410(2)	3.08(5)
C(4)	-0.0920(3)	-0.2438(2)	0.8212(2)	3.72(5)
C(5)	-0.0008(4)	-0.3301(3)	0.7942(2)	4.90(7)
C(6)	-0.1079(5)	-0.4443(3)	0.7575(2)	6.34(9)
C(7)	-0.3097(6)	-0.4740(3)	0.7470(3)	7.27(10)
C(8)	-0.3996(5)	-0.3902(3)	0.7749(3)	7.94(11)
C(9)	-0.2946(4)	-0.2770(3)	0.8124(3)	5.80(8)
C(10)	-0.1979(3)	-0.0000(2)	0.7731(2)	3.04(5)
C(11)	-0.1816(3)	0.0343(2)	0.6859(2)	3.11(5)
C(12)	-0.3413(3)	0.0597(2)	0.6249(2)	4.09(6)
C(13)	-0.5208(3)	0.0480(3)	0.6489(2)	4.59(6)
C(14)	-0.5413(3)	0.0124(3)	0.7333(2)	4.23(6)
C(15)	-0.3812(3)	-0.0107(2)	0.7954(2)	3.78(5)
C(16)	0.1635(3)	0.1890(2)	0.8980(2)	3.39(5)
C(17)	0.3414(3)	0.2545(2)	0.8896(2)	4.25(6)
C(18)	0.3673(4)	0.3708(3)	0.8980(2)	5.32(7)
C(19)	0.2199(5)	0.4246(3)	0.9136(2)	6.05(8)
C(20)	0.0443(4)	0.3595(3)	0.9208(2)	5.73(8)
C(21)	0.0160(4)	0.2424(2)	0.9148(2)	4.42(6)
C(22)	-0.0858(5)	-0.2655(3)	0.4876(2)	6.07(8)
C(23)	-0.2636(7)	-0.2903(5)	0.5278(4)	10.4(1)
C(24)	0.0922(8)	-0.2944(5)	0.5509(4)	11.6(2)
C(25)	-0.1351(9)	-0.3230(4)	0.3794(3)	11.0(2)

$B_{eq} = (8/3)\pi^2[U_{11}(aa^*)^2 + U_{22}(bb^*)^2 + U_{33}(cc^*)^2 + 2U_{12}(aa^*bb^*)\cos\gamma + 2U_{13}(aa^*cc^*)\cos\beta + 2U_{23}(bb^*cc^*)\cos\alpha]$

C-3 δ 159.0-159.8 ppm; C-4 δ 105.4-110.1 ppm; C-5 was not distinguished from other aromatic carbon absorptions.

The yields of dihydropyrazolones **4-13** may not be optimal, especially for a particular compound, but the current general procedure readily affords multi-gram quantities of pure products resulting from recrystallization from common solvents. They are in sufficient amounts for biological testing, spectral characterization, and other uses. Also, the starting materials, especially the wide variety of esters, are more readily available than starting materials used with other synthetic methods [4-6]. The experimental procedure is straightforward so that someone not necessarily familiar with strong base procedures can be successful with the reactions, and the experimental set-up does not require an elaborate apparatus.

This initial study indicates that these polylithiated intermediates and related intermediates (*e.g.*, *N*-methyl or *N*-carboalkoxy, etc.) have potential for condensation with additional esters and related electrophilic compounds (*e.g.*, ketones) for the preparation of new materials that may be difficult to prepare, or even inaccessible by some of the current synthetic methods [4-15].

EXPERIMENTAL

Melting points were obtained with a Mel-Temp II melting point apparatus in open capillary tubes and are uncorrected. Fourier transform infrared spectra were obtained on a Nicolet Impact 410 FT-IR. Proton and ^{13}C nuclear magnetic resonance spectra were obtained with a Varian Associates Mercury Oxford 300 MHz nuclear magnetic resonance spectrometer, and chemical shifts were recorded in δ ppm downfield from an internal tetramethylsilane standard. Combustion analyses were performed by Quantitative Technologies, Inc., P.O. Box 470, Salem Industrial Park, Whitehouse, NJ 08888. The tetrahydrofuran was distilled from sodium (benzophenone ketyl as an indicator of dryness) prior to use, and organic chemicals were obtained from Aldrich Chemical Co.

Table 3

Selected Bond Distances (Å) and Angles (°) for **8**, $C_{21}H_{16}N_2O_2 \cdot C_4H_{10}O$

O1	C1		1.352(4)	O2	C11		1.381(3)
N1	N2		1.391(3)	N1	C1		1.316(4)
N2	C3		1.371(4)	N2	C16		1.417(4)
C1	C2		1.425(4)	C2	C3		1.382(4)
C2	C4		1.476(5)	C3	C10		1.490(4)
C4	C5		1.386(5)	C4	C9		1.392(5)
C5	C6		1.387(6)	C6	C7		1.380(6)
C7	C8		1.359(7)	C8	C9		1.375(6)
C10	C11		1.390(4)	C10	C15		1.402(4)
C11	C12		1.387(4)	C12	C13		1.386(4)
C13	C14		1.365(4)	C14	C15		1.383(4)
C16	C17		1.395(4)	C16	C21		1.387(5)
C17	C18		1.362(5)	C18	C19		1.385(6)
C19	C20		1.374(6)	C20	C21		1.373(5)
O1	H1		0.92	O2	H2		0.94
N2	N1	C1	104.7(2)	N1	N2	C3	111.0(2)
N1	N2	C16	119.3(2)	C3	N2	C16	129.7(2)
O1	C1	N1	121.8(3)	O1	C1	C2	125.4(3)
N1	C1	C2	112.8(3)	C1	C2	C3	104.1(3)
C1	C2	C4	125.9(3)	C3	C2	C4	130.0(3)
N2	C3	C2	107.4(2)	N2	C3	C10	120.8(3)
C2	C3	C10	131.5(3)	C2	C4	C5	120.4(3)
C2	C4	C9	122.4(3)	C5	C4	C9	117.2(3)
C4	C5	C6	121.4(4)	C5	C6	C7	120.0(4)
C6	C7	C8	118.9(4)	C7	C8	C9	121.6(4)
C4	C9	C8	120.9(4)	C3	C10	C11	120.3(2)
C3	C10	C15	121.9(2)	C11	C10	C15	117.8(2)
O2	C11	C10	117.6(2)	O2	C11	C12	122.0(2)
C10	C11	C12	120.4(2)	C11	C12	C13	120.3(3)
C12	C13	C14	120.2(3)	C13	C14	C15	119.6(3)
C10	C15	C14	121.5(3)	N2	C16	C17	119.5(3)
N2	C16	C21	120.4(3)	C17	C16	C21	120.1(3)
C16	C17	C18	119.0(3)	C17	C18	C19	121.3(4)
C18	C19	C20	119.4(4)	C19	C20	C21	120.5(4)
C16	C21	C20	119.7(3)	O3	C22	C23	108.2(4)
C1	O1	H1	106	C11	O2	H2	108

Single crystal X-ray measurements for crystals of **8**, $C_{21}H_{16}N_2O_2 \cdot C_4H_{10}O$ ($C_{25}H_{26}N_2O_3$), were collected on a Mercury CCD area detector coupled with a Rigaku AFC8 diffractometer with graphite monochromated Mo-Kα radiation (Clemson University). The data were collected at a temperature of 20 $\pm$ 1 °C to a maximum 2θ value of 52.9°. Data were collected in 0.50° oscillations with 15.0 s exposures (two identical scans were performed at each position to identify detector anomalies). A sweep of data was done using ω oscillations from -90.0° to 90.0° at χ = 45.0° and ϕ = 0.0°. A second sweep was performed using ω oscillations from -300.0° to 30.0° at χ = 45.0° and ϕ = 90.0°. The crystal-to-detector distance was 26.92 mm. The detector swing angle was 0.00°. Cell parameters and additional details of the data collection are reported in Table 1.

Of the 10627 reflections, which were collected, 4543 were unique (R_{int} = 0.051); equivalent reflections were merged. Data were collected and processed using CrystalClear (Rigaku) [45]. The structure was solved by direct methods [46] and expanded using Fourier techniques [47]. The non-hydrogen atoms were refined anisotropically. Hydrogen atoms were included but not refined. The final cycle of full-matrix least-squares refinement [48] on *F* was based on 2644 observed reflections ($I > 3.00\sigma(I)$) and 271 variable parameters and converged (largest parameter shift was 0.00 times its esd) with R = 0.065 and R_w = 0.069.

The standard deviation of an observation of unit weight [49] was 1.86. The weighting scheme was based on counting statistics. Plots of $\Sigma w (|F_o| - |F_c|)^2$ versus $|F_o|$, reflection order in data collection, $\sin\theta/\lambda$ and various classes of indices showed no unusual trends. The maximum and minimum peaks on the final difference Fourier map corresponded to 0.17 and -0.20 e Å^{-3}, respectively. Further data are available on request from the authors C.R.M. or W.T.P.

Neutral atom scattering factors were taken from Cromer and Waber [50]. Anomalous dispersion effects were included in F_{calc} [51]; the values for Δf' and Δf" were those of Creagh and McAuley [52]. The values for the mass attenuation coefficients are those of Creagh and Hubbell [53]. All calculations were performed using the teXsan [54] crystallographic software package of Molecular Structure Corporation.

General Experimental Procedure for Preparing 2'-Phenylphenylacetohydrazides (**1-3**).

The entry compounds were prepared by a minor modification of documented preparations [55] where equal amounts of the phenylacetic acid (15 g - 0.11 mol) and phenylhydrazine (15 g -0.14 mol) were heated under reflux for several hours using toluene (125-150 ml) as the solvent. After reducing the volume of the solution to 50-75 ml, crystallization usually occurred, and after filtration, the product was recrystallized from toluene. The work-up of a second crop for optimization of yield was not usually undertaken, and the emphasis was placed on purity and dryness of phenylhydrazides.

2'-Phenylphenylacetohydrazide (**1**).

This compound was prepared by the general procedure from the condensation of 15 g (0.11 mol) of phenylacetic acid and 15 g (0.14 mol) of phenylhydrazine to yield 17.4 g (70 %); mp 173-175° (toluene)(lit. mp 175° [56]).

2'-Phenyl-(4-chlorophenyl)acetohydrazide (**2**).

This compound was prepared by the general procedure from the condensation of 15 g (0.088 mol) of 4-chlorophenylacetic acid and 15 g (0.14 mol) of phenylhydrazine to yield 13.07 g (57%); mp 168-170° (toluene). Infrared (paraffin oil): 3313, 3238 (broad), 3089, 3029, 1685 (shoulder) and 1633 cm^{-1}. ^{1}H nmr (DMSO-d_6): δ (ppm) 3.54 (s, 2H, -CH_2-), 6.68-6.73, 7.10-7.42 (m, 9H, ArH), 7.80 (s, NH), and 9.95 (s, NH); ^{13}C nmr (DMSO-d_6): δ (ppm) 39.7, 112.1, 118.6, 128.2, 128.7, 130.9, 131.3, 134.9, 149.3, and 169.7.

Anal. Calcd. for $C_{14}H_{13}ClN_2O$: C, 64.40; H, 5.03; N, 10.74. Found: C, 64.32; H, 5.16; N, 10.57.

2'-Phenyl-(4-methoxyphenyl)acetohydrazide (**3**).

This compound was prepared by the general procedure from the condensation of 15 g (0.090 mol) of 4-methoxphenylacetic acid and 15 g (0.14 mol) of phenylhydrazine to yield 8.53 g (37 %); mp 175-178° (toluene). Infrared (paraffin oil) 3286, 3203 (broad), 3195, 3084, 1660 and 1635 cm^{-1}. ^{1}H nmr (DMSO-d_6): δ (ppm) 3.45 (s, 2H, -CH_2-), 3.73 (s, 3H, ArOCH_3), 6.68-7.28 (m, 9H, ArH), 7.75 (s, NH), and 9.86 (s, NH); ^{13}C nmr (DMSO-d_6): δ (ppm) 39.6, 55.1, 112.1, 118.5, 128.7, 128.8, 128.9, 132.8, 135.5, 149.3, and 170.1.

Anal. Calcd. for $C_{15}H_{16}N_2O_2$: C, 70.29; H, 6.29; N, 10.93. Found: C, 70.36; H, 6.41; N, 10.94.

General Experimental Procedure for Preparing 4,5-Disubstituted, 1,2-Dihydro-3*H*-pyrazol-3-ones, **4-13.**

In a typical reaction sequence, lithium diisopropylamide (0.063 mol for **4-7**, **12** and **13** or 0.079 mol for **8** and **9**) was prepared by the addition of 39 or 49 ml of 1.6 *M n*-butyllithium in hexanes (0.063 mol for **4-7**, **12** and **13**, or 0.079 mol for **8** and **9**) to a three-neck round-bottomed flask (*e.g*., 500 ml), equipped with a nitrogen inlet tube, a side-arm addition funnel (*e.g*., 125 ml), and a magnetic stir bar (ratio of reagents - phenylhydrazide: lithium diisopropylamide: ester - 1:4:1 for **4-7** and **12-13**; 1:5:1 for **8** and **9**: 5% molar excess of base and ester). The flask was cooled in an ice water bath and 6.41 g or 8.02 g (0.063 mol for **4-7**, **12** and **13**, or 0.079 mol for **8** and **9**) of diisopropylamine, dissolved in 25-30 ml of dry tetrahydrofuran, was added from the addition funnel at a fast dropwise rate during a 5 minute period (0°, nitrogen). The solution was stirred for an additional 15-20 minutes, and then rapidly treated *via* a powder funnel, with a slurry of 0.015 mol of phenylhydrazide and 50 ml of dry tetrahydrofuran. After 2 hours of polylithiation, 0.016 mol of ester, dissolved in 25-35 ml of tetrahydrofuran, was added, during 5 minutes, to the polylithiated intermediate, and the solution was stirred and condensed for 60 minutes (0°, nitrogen) for **4-7** and **10-13** and 2 hours for **8** and **9**. Finally, 100 ml of 3*N* hydrochloric acid was added quickly, and the two-phase mixture was well stirred and heated under reflux for approximately 60 minutes. At the end of this period, the mixture was poured into a large flask containing ice (*ca*., 100 g), followed by the addition of 100 ml of solvent grade ether. The mixture was then neutralized with solid sodium bicarbonate, and the liquid layers or solid materials separated. If a solid appeared at this point, the biphasic mixture could be filtered using a large Buchner funnel. The aqueous layer was extracted with ether or tetrahydrofuran (2x75 ml), and the organic fractions were combined, dried, filtered, evaporated, and recrystallized.

1,2-Dihydro-1,4,5-triphenyl-3*H*-pyrazol-3-one (**4**).

This compound was prepared by the general procedure from the condensation-cyclization of 0.015 mol of trilithiated phenylhydrazide **1** and 0.016 mol of methyl benzoate to yield 3.88 g (83%), mp 283-285° (ethanol-toluene) (lit. mp [6] 282°). Infrared (paraffin oil) 3100-3300 cm^{-1} (shoulder), 1615 and 1596 cm^{-1}. ^1H nmr (DMSO-d_6): δ (ppm) 7.07-7.33 (m, 15H, ArH)[57]; ^{13}C nmr (DMSO-d_6): δ (ppm) 107.0, 124.2, 125.5, 126.1, 127.8, 128.3, 128.49 (2), 128.54, 130.0, 130.3, 131.6, 139.4, 139.7, and 159.3.

Anal. Calcd. for $C_{21}H_{16}N_2O$: C, 80.75; H, 5.16; N, 8.97. Found: C, 80.38; H, 5.32; N, 8.87.

1,2-Dihydro-1,4-diphenyl-5-(4-methoxyphenyl)-3*H*-pyrazol-3-one (**5**).

This compound was prepared by the general procedure from the condensation-cyclization of 0.015 mol of trilithiated phenylhydrazide **1** and 0.016 mol of methyl 4-methoxybenzoate to yield 4.98 g (97%), mp 270-272° (ethanol-toluene). Infrared (paraffin oil) 3441 (broad), 3324, 3187, 1653, 1615 and 1595 cm^{-1}. ^1H nmr (DMSO-d_6): δ (ppm) 3.73 (s, 3H, $ArOCH_3$), 6.80-6.91, 7.06-7.30 (m, 14H, ArH) and 10.61 (s, NH or OH); ^{13}C nmr (DMSO-d_6): δ (ppm) 55.1, 106.8, 114.1, 122.4, 124.4, 125.6, 126.2, 127.9, 128.4, 128.7, 128.8, 131.5, 131.9, 139.7, 148.3, and 159.2.

Anal. Calcd. for $C_{22}H_{18}N_2O_2$: C, 77.17; H, 5.30; N, 8.18. Found: C, 77.35; H, 5.46; N, 7.99.

1,2-Dihydro-5-(4-chlorophenyl)-1,4-diphenyl-3*H*-pyrazol-3-one (**6**).

This compound was prepared by the general procedure from the condensation-cyclization of 0.015 mol of trilithiated phenylhydrazide **1** and 0.016 mol of methyl 4-chlorobenzoate to yield 3.12 g (58%); mp 301° d (1-propanol-toluene). Infrared (paraffin oil) 3374 (broad), 1617 and 1598 cm^{-1}. ^1H nmr (DMSO-d_6): δ (ppm) 7.12-7.43 (m, 14H, ArH) [57]; ^{13}C nmr (DMSO-d_6): δ (ppm) 107.3, 124.7, 125.9, 126.6, 128.1, 128.6, 128.81, 128.84, 129.3, 131.5, 132.1, 133.5, 138.6, 139.3, and 159.5.

Anal. Calcd. for $C_{22}H_{15}ClN_2O$: C, 72.73; H, 4.36; N, 8.08. Found: C, 72.85; H, 4.53; N, 8.02.

1,2-Dihydro-1,4-diphenyl-5-(4-methylphenyl)-3*H*-pyrazol-3-one (**7**).

This compound was prepared by the general procedure from the condensation-cyclization of 0.015 mol of trilithiated phenylhydrazide **1** and 0.016 mol of methyl 4-methylbenzoate to yield 2.54 g (52%); mp 280-283° (toluene). Infrared (paraffin oil), 3350 (broad), 1653, and 1595 cm^{-1}. ^1H nmr (DMSO-d_6): δ (ppm) 2.27 (s, 3H, $ArCH_3$), 7.01-7.30 (m, 14H, ArH), and 10.60 (s, NH or OH); ^{13}C nmr (DMSO-d_6): δ (ppm) 20.9, 107.0, 124.4, 125.6, 126.3, 127.4, 127.9, 128.5, 128.7, 129.3, 130.0, 131.8, 138.0, 139.4, 139.9, and 159.4.

Anal. Calcd. for $C_{22}H_{18}N_2O$: C, 80.96; H, 5.56; N, 8.58. Found: C, 80.71; H, 5.77; N, 8.33**.**

1,2-Dihydro-1,4-diphenyl-5-(2-hydroxyphenyl)-3*H*-pyrazol-3-one (**8**).

This compound was prepared by the general procedure from the condensation-cyclization of 0.015 mol of trilithiated phenylhydrazide **1** and 0.016 mol of lithiated methyl salicylate to yield 2.71 g (55%); mp 289-290° (ethanol-toluene). Infrared (paraffin oil) 3546, 3500, 3452, 1614 (shoulder), and 1598 cm^{-1}. ^1H nmr (DMSO-d_6): δ (ppm) 6.73-7.27 (m, 14H, ArH), 9.77 (s, 1H, OH), and 10.58 (s, 1H, NH or OH); ^{13}C nmr (DMSO-d_6): δ (ppm) 107.3, 115.7, 118.1, 119.2, 122.9, 125.3, 125.8, 127.6, 127.8, 128.5, 130.7, 131.8, 132.4, 137.4, 140.2, 156.1, and 159.4.

Anal. Calcd. for $C_{21}H_{16}N_2O_2$: C, 76.81; H, 4.91; N, 8.53. Found: C, 76.84; H, 4.88; N, 8.33.

The crystals used for X-ray analysis, mp 290-292° (*tert*-butyl alcohol): Infrared 3537, 3477 (sharp), 3452 (broad), and 1593 cm^{-1}. ^1H nmr (DMSO-d_6): δ (ppm) 1.12 (s, 9H, $C(CH_3)_3$), 4.02 (s, 1H, OH), 6.74-7.31 (m, 14H, ArH), 9.76 (s, 1H, OH), and 10.56 (s, 1H, NH or OH); ^{13}C nmr (DMSO-d_6): δ (ppm) 31.3, 67.0, 107.3, 115.7, 118.2, 119.2, 122.9, 125.3, 125.8, 127.6, 127.8, 128.5, 130.7, 131.8, 132.4, 137.4, 140.2, 156.1, and 159.4.

Anal. Calcd. for $C_{21}H_{16}N_2O_2 \bullet C_4H_{10}O$ ($C_{25}H_{26}N_2O_3$): C, 74.60: H, 6.51; N, 6.96. Found: C, 74.87; H, 6.26; N, 7.26.

1,2-Dihydro-1,4-diphenyl-5-(2-hydroxy-3-methoxyphenyl)-3*H*-pyrazol-3-one (**9**).

This compound was prepared by the general procedure from the condensation-cyclization of 0.015 mol of trilithiated phenylhydrazide **1** and 0.016 mol of lithiated methyl 3-methoxysalicylate to yield 4.03 g (75%); mp 272-274° (ethanol). Infrared (paraffin oil) 3501, 3168 (broad shoulder), 1625, 1614, and 1592 cm^{-1}. ^1H nmr (DMSO-d_6): δ (ppm) 3.76 (s, 3H, $ArOCH_3$), 6.61

(t, 1H, ArH), 6.71 (d, 1H, ArH), [58] and 6.95-7.32 (m, 11H, ArH), 8.97 (s, OH), 10.59 (s, NH or OH); ^{13}C nmr (DMSO-d_6): δ (ppm) 55.7, 107.3, 112.6, 118.3, 119.2, 122.9, 123.3, 125.4, 125.9, 127.6, 127.9, 128.6, 132.4, 137.0, 140.2, 145.4, 147.6, and 159.4.

Anal. Calcd. for $C_{22}H_{18}N_2O_3$: C, 73.73; H, 5.06; N, 7.82. Found: C, 73.62; H, 4.81; N, 7.95.

1,2-Dihydro-1,4-diphenyl-5-(3,4,5-trimethoxyphenyl)-3*H*-pyrazol-3-one (**10**).

This compound was prepared by the general procedure from the condensation-cyclization of 0.015 mol of trilithiated phenylhydrazide **1** and 0.016 mol of methyl 3,4,5-trimethoxybenzoate to yield 5.19 g (86%); mp 270-273° (xylenes-dimethylformamide). Infrared (paraffin oil) 3374, 1660, 1602, and 1581 cm^{-1}. ^{1}H nmr (DMSO-d_6): δ (ppm) 3.46 (s, 6H, $ArOCH_3$), 3.65 (s, 3H, $ArOCH_3$), 6.41 (s, 2H, ArH), and 7.14-7.36 (m, 10H, ArH), and 10.59 (s, NH or OH); ^{1}H nmr (trifluoroacetic acid-d): δ (ppm) 3.48 (s, 6H, $ArOCH_3$), 3.86 (s, 3H, $ArOCH_3$), 6.42 (s, 2H, ArH), and 7.31-7.51 (m, 10H, ArH), and 11.50 (s, NH or OH); ^{13}C nmr (DMSO-d_6): δ (ppm) 55.7, 60.2, 106.8, 107.8, 124.7, 125.3, 125.8, 126.5, 127.9, 128.68, 128.74, 131.8, 137.6, 139.7, 139.8, 152.7, and 159.4.

Anal. Calcd. for $C_{24}H_{22}N_2O_4$: C, 71.63; H, 5.51; N, 6.96. Found: C, 71.91; H, 5.61; N, 6.97.

3-Oxo-2-phenyl-3-(3,4,5-trimethoxyphenyl)propanoic Acid, 2-Phenylhydrazide (**10a**).

This compound was prepared by the general procedure excluding the cyclization step from the condensation of 0.015 mol of trilithiated phenylhydrazide **1** and 0.016 mol of methyl 3,4,5-trimethoxybenzoate to yield 4.80 g (76%); mp 214-218° (xylenes). Infrared (paraffin oil) 3273 (broad), 1676 and 1668 cm^{-1}. ^{1}H nmr (deuteriochloroform): δ (ppm) 3.56 (s, 1H, CH), 3.58 (s, 6H, $ArOCH_3$), 3.79 (s, 3H, $ArOCH_3$), 6.66 (s, 2H, ArH), 7.16-7.30 (m, 10H, ArH), and 8.52 (s, NH or OH); ^{13}C nmr (deuteriochloroform): δ (ppm) 41.5, 56.1, 61.0, 106.5, 125.8, 127.3, 127.6, 128.8, 129.0, 129.1, 129.5, 133.7, 140.1, 144.9, 152.6, 169.5 and 170.7.

Anal. Calcd. for $C_{24}H_{24}N_2O_5$: C, 68.55; H, 5.75; N, 6.66. Found: C, 68.41; H, 5.78; N, 6.60.

1,2-Dihydro-1,4-diphenyl-5-(4-(1,1-dimethylethylphenyl)-3*H*-pyrazol-3-one (**11**).

This compound was prepared by the general procedure from the condensation-cyclization of 0.015 mol of trilithiated phenylhydrazide **1** and 0.016 mol of ethyl 4-*t*-butylbenzoate to yield 3.42 g (62%); mp 310-312° (xylenes-dimethylformamide). Infrared (paraffin oil) 3400 (broad), 1620 and 1596 cm^{-1}. ^{1}H nmr (DMSO-d_6): δ 1.24 (s, 9H, $ArC(CH_3)_3$), 7.07-7.37 (m, 14H, ArH,), and 10.58 (s, NH or OH); ^{13}C nmr (DMSO-d_6): δ 30.9, 34.3, 106.9, 124.1, 125.0, 125.4, 126.0, 127.2, 127.6, 128.26, 128.32, 129.6, 131.6, 139.5, 139.7, 150.9, and 159.1.

Anal. Calcd. for $C_{25}H_{24}N_2O$: C, 81.49; H, 6.56; N, 7.60. Found: C, 81.53; H, 6.48; N, 7.43.

1,2-Dihydro-4,5-di-(4-methoxyphenyl)-1-phenyl-3*H*-pyrazol-3-one (**12**).

This compound was prepared by the general procedure from the condensation-cyclization of 0.015 mol of trilithiated phenylhydrazide **2** and 0.016 mol of methyl 4-methoxybenzoate to yield 4.52 g (81%); mp 275-277° (xylenes-dimethylformamide). Infrared (paraffin oil) 3300-3100 (shoulder), 1618, and 1593 cm^{-1}. Infrared (KBr) 1646, 1616, and 1596 cm^{-1}. ^{1}H nmr (trifluoroacetic acid-d): δ (ppm) 3.79 (s, 3H, $ArOCH_3$), 3.89 (s, 3H, $ArOCH_3$), and 6.81-7.43 (m, 13H, ArH); ^{13}C nmr (DMSO-d_6): δ (ppm) 54.9, 55.0, 106.5, 113.4, 114.0, 122.4, 123.9, 124.1 (2), 125.9, 128.5, 129.4, 131.3, 139.1, 139.6, 157.1, and 159.0.

Anal. Calcd. for $C_{23}H_{20}N_2O_3$: C, 74.18; H, 5.41; N, 7.52. Found: C, 74.11; H, 5.29; N, 7.53.

1,2-Dihydro-4-(4-chlorophenyl)-1,5-diphenyl-3*H*-pyrazol-3-one (**13**).

This compound was prepared by the general procedure from the condensation-cyclization of 0.015 mol of trilithiated phenylhydrazide **3** and 0.016 mol of methyl benzoate to yield 2.81 g (54%); mp 302-304° (xylenes-dimethylformamide). Infrared (paraffin oil) 3300-3200 (shoulder) 1659, 1616, and 1598 cm^{-1}. ^{1}H nmr (DMSO-d_6): δ (ppm) 7.05-7.41 (m, 14H, ArH) and 10.71 (s, NH or OH); ^{13}C nmr (DMSO-d_6): δ (ppm) 105.8, 124.5, 126.5, 128.0, 128.5, 128.7, 128.8, 130.0, 130.1, 130.2, 130.3, 130.7, 139.4, 140.1, and 159.4.

Anal. Calcd. for $C_{21}H_{15}ClN_2O$: C, 72.73; H, 4.36; N, 8.07. Found: C, 72.83; H, 4.37; N, 8.40.

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[43] Most of the products did not display a clearly assignable carbonyl absorption between 1620-1680 cm^{-1}, or a convincing or definitive OH absorption in the region 3100-3500 cm^{-1}.

[44] This example was chosen because the condensation-cyclization of trilithiated **1** with lithiated methyl thiosalicylate did not give the analogous dihydropyrazolone with a pendent phenyl mercaptan pendant group in position 5. An isothioflavone was obtained instead, which will be reported on completion with other results separately.

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[56] See ref. [55], p. 568.

[57] The ^{1}H nmr spectrum of **4** and **6** did not display NH/OH absorptions.

[58] A comparative ^{1}H nmr spectrum was obtained from methyl 3-methoxysalicylate, and it displayed apparent (δ) t, 6.78, d, 7.00 and d, 7.39 ppm. A similar spectral splitting as observed with this product **9** for the two upfield proton absorptions.