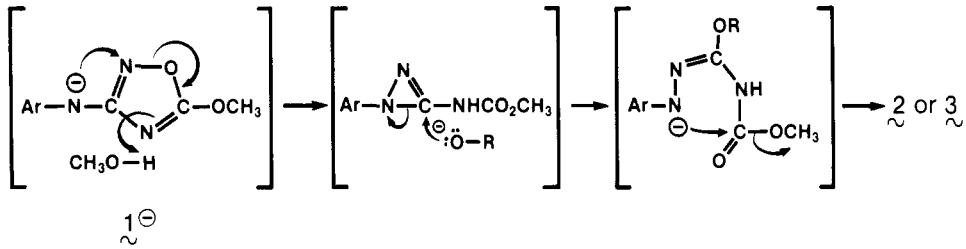
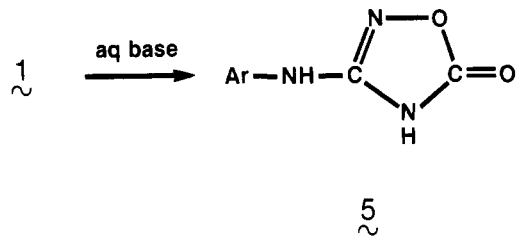
Table II. Yields and Physical Data of 2 and 3

compd	mp, °C	yield, %	anal., % calcd C, H, N	anal., % found C, H, N
2b, $C_9H_8ClN_3O_2$	198–199	82	47.91, 3.57, 18.62	47.74, 3.79, 18.40
2c, $C_9H_7Cl_2N_3O_2$	269–272	95	41.56, 2.71, 16.16	41.77, 2.84, 16.40
2d, $C_{13}H_{17}N_3O_2$	135–138	65	63.14, 6.93, 16.99	63.39, 6.90, 17.36
3a, $C_{10}H_{11}N_3O_2$	148–150	57	58.53, 5.40, 20.48	58.69, 5.82, 20.71
3b, $C_{10}H_{10}ClN_3O_2$	176–178	85	50.12, 4.21, 17.53	49.48, 3.90, 17.73
3c, $C_{10}H_9Cl_2N_3O_2$	241–243	91	43.98, 3.31, 15.33	43.93, 3.14, 15.52

Scheme II



Scheme III



separated and 10% NaOH (20 mL) was added with stirring. The resulting mixture was stirred at room temperature for 1 h, after which the methylene chloride layer was separated, washed with water and saturated NaCl solution, dried ($MgSO_4$), and evaporated to give 2.5 g of solid. Recrystallization from toluene/petroleum ether (bp 35–60 °C) gave 1.8 g (73%) of light-yellow crystals. The product was further purified by column chromatography to give pure white fluffy solid: mp 77–78 °C; mass spectrum (70 eV), 247 (M^+); ^1H NMR ($CDCl_3$) δ 8.10 and 7.05 (ab q, 4), 3.90 (s, 3), 2.55 (t, 2), 1.6–1.0 (m, 7); IR (KBr) 3300, 1595, 1545, 1350 cm^{-1}. Anal. Calcd for $C_{13}H_{17}N_3O_2$: C, 63.14; H, 6.93; N, 16.99. Found: C, 63.01; H, 6.86; N, 16.84.

Rearrangement of 1a to 2a in $NaOCH_3/CH_3OH$. A 2.2-g (0.01 mol) sample of 25% sodium methoxide in methanol was added to a 2.0-g (0.01 mol) sample of **1a** in 25 mL of methanol. The resulting solution was heated under reflux for 3 h. The solution was cooled to room temperature and neutralized with 10% HCl. A light-yellow precipitate formed. The precipitate was collected and washed with water. Recrystallization from methanol gave 0.95 g (48%) of white crystals: mp 192–194 °C (lit.[16,17] mp 197, 197–198 °C); mass spectrum (70 eV), 191 (M^+); ^1H NMR (Me_2SO-d_6) δ 7.9–7.1 (m, 5), 3.95 (s, 3); IR (KBr) 3060–2680, 1720, 1660, 1600, 1500, 1340, 1315 cm^{-1}. Anal. Calcd for $C_9H_9N_3O_2$: C, 56.54; H, 4.74; N, 21.98. Found: C, 56.69; H, 4.94; N, 22.10.

Rearrangements of other oxadiazoles (**1b–1d**) were carried out in similar fashion. The yields, physical properties, and elemental analyses of **2** and **3** are listed in Table II.

Base Hydrolysis of 1a to 5. To 0.2 g (1.0 mmol) of **1a** in 5 mL of methanol was added 1.5 mL of 20% aqueous NaOH. The mixture was heated to reflux for 45 min. After cooling to room temperature the mixture was quenched with 5 mL of 10% HCl. A fine white powder precipitated from solution. Recrystallization from $MeOH/H_2O$ (1:1, v/v) gave 0.13 g (0.74 mmol; 74%), mp 186–187 °C dec. Anal. Calcd for $C_8H_7N_3O_2$: C, 54.24; H, 3.95; N, 23.73. Found: C, 54.78; H, 3.90; N, 24.50.

X-ray Data Collection.[23] Full details of the X-ray data collection and structure solution and refinement are available.

(23) Molecular structures Corporation, College Station, TX.

(See paragraph at the end of paper about supplementary material.)

Acknowledgment. Spectral measurements by SK&F Chemical Analysis Group are gratefully appreciated. We thank Dr. I. J. Turchi, Dr. C. E. Berkoff, and Dr. R. L. Webb for many helpful discussions.

Registry No. 1a, 58598-94-0; **1b**, 58599-07-8; **1c**, 59496-76-3; **1d**, 81012-74-0; **2a**, 14500-22-2; **2b**, 81012-75-1; **2c**, 81012-76-2; **2d**, 81012-77-3; **3a**, 14495-36-4; **3b**, 81012-78-4; **3c**, 81012-79-5; **5**, 81012-80-8; *N*-(*p*-*n*-butylphenyl)-*N'*-carbmethoxyguanidine, 81012-81-9.

Supplementary Material Available: X-ray data collection, structure solution and refinement description; tables for crystal data, least-squares plane calculations, intramolecular bond distances and angles, and atomic coordinates (8 pages). Ordering information is given on any current masthead page.

Structure of 2-Acetyl-6-(dimethylamino)fulvene and Its Reactions with Primary and Secondary Amines[1]

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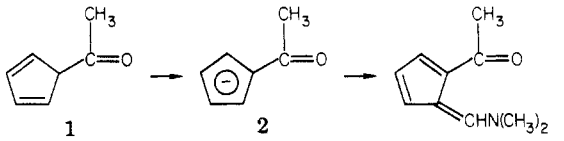
Received September 9, 1981

In connection with studies on derivatives of cyclopenta[*d*]pyridazines[2] it was desired to prepare 2-acetyl-6-(dimethylamino)fulvene (**3**) as a possible intermediate to 1-methyl derivatives and examine its reactions with primary and secondary amines. Fijisawa and Sakai[3] had reported the synthesis of **3** by (i) the acetylation of sodium cyclopentadienide with ethyl acetate to form acetylcyclopentadiene **1**, (ii) treatment of **1** with 1 equiv of ethoxide to form **2**, and (iii) reaction of **2** with dimethylformamide, phosphorus oxychloride, and 3 equiv of methoxide. In our hands acetyl chloride was a better acetylation reagent, and the generation of **2** with 1 equiv of methoxide followed by treatment with the Vilsmeier reagent from dimethylform-

(1) R.P.K. Ph.D. Thesis, University of Washington, 1981.
(2) Anderson, A. G., Jr.; Tober, T. Y. *J. Org. Chem.* **1980**, *45*, 1695 and references therein.
(3) Fujisawa, T.; Sakai, K. *Tetrahedron Lett.* **1976**, 3331.

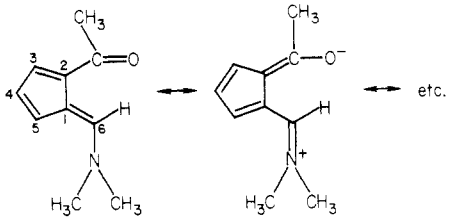
0022-3263/82/1947-1971$01.25/0

amide and dimethyl sulfate gave the best yields (55% from cyclopentadiene) of **3** and significantly shortened the overall time.

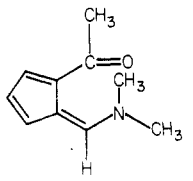


1 2 3

The enamine function in **3** could have an anti (*E*, **3a**) or a syn (*Z*, **3b**)geometric orientation relative to the acetyl



3a

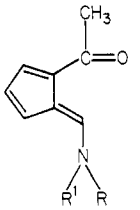


3b

substituent. Molecular models indicated that the contribution of resonance structures (e.g., as shown) would be sterically more favorable for the *E* structure. If so, consideration of the various resonance structures (and that the noncharge-separated structure would contribute more to the ground state than any charge-separated one) and the anisotropy of the carbonyl group led to the qualitative prediction that the H-3 would be less shielded than H-5 and that the double bond character of the bond joining C-4 and C-5 would be a little more than for the bond joining C-3 and C-4. Therefore, the ^{1}H NMR doublet signals at δ 7.1 and 6.9 were assigned to H-3 and H-5 with $j_{3,4}$ = 4.0 Hz and $J_{4,5}$ = 4.2 Hz, respectively. The contribution of dipolar resonance structures having the CH=$N(CH_3)_2^+$ group and, consequently, restricted rotation about the C–N bond was shown by the appearance of two ^{1}H NMR signals (δ 3.3 and 3.4) for those methyl groups[4] and a singlet (δ 9.02) for H-6. The pronounced downfield shift for the latter could be due, in part, to its orientation toward the carbonyl group. Partial conjugation with the acetyl group, but allowing relatively rapid rotation, was indicated by the IR carbonyl absorption at 1610 cm^{-1}[3] and a single ^{1}H NMR peak for the methyl of the acetyl group. Additional support for the *E* geometry of **3** was provided by a T_1 spin–lattice relaxation experiment which showed relative relaxation rates for the olefinic hydrogens of 0.29 (H-3), 0.27 (H-4), and 0.37 s^{-1} (H-5) (Figure 1) in accord with the enhancement of the relaxation rates for H-5 and, to a lesser extent, H-3 by the proximities of an $=^+N(CH_3)_2$ methyl and acetyl methyl, respectively.[5]

Reaction of 3 with Primary Amines. The reaction of **3** with primary or secondary amines would be a reversible process. Accordingly, an excess of the amines was used. In all cases the product was that formed by reaction at C-6, with none from reaction at the acetyl group being detected.

Treatment of **3** with an excess of hydroxylammonium chloride in the presence of triethylamine or pyridine gave 2-acetyl-6-(hydroxyamino)fulvene (**4**). Similarly, reaction



4, R = OH; R^1 = H
5, R = CH_2CH_2OH; R^1 = H
6, R = C_6H_5; R^1 = H
7, *p*-$C_6H_4NHCH_3$; R^1 = H
8, *o*-$C_6H_5NH_2$; R^1 = H
9, R = NHC_6H_5; R^1 = H
10, R, R^1 = $(CH_2)_5$
11, R = R^1 = $CH(CH_3)_2$

with 2-aminoethanol, aniline, *p*-(methylamino)aniline, *o*-aminoaniline, or phenylhydrazine afforded the corresponding derivatives **5–9**, respectively. The UV, IR, and ^{1}H NMR spectra and elementary analyses of the products were in agreement with the structures shown. The yields ranged from 35% for **4** to 89.5% for **8**. The signals for H-6 were doublets in each case, showing coupling with the adjacent N–H, and for one compound (**4**) the resolution of the broad N–H signal was sufficient to provide confirmation of this. It was noted that replacement of the *N*-alkyl group in **5** with an aryl group (**6–8**) resulted in a shift of the longest wavelength UV absorption from 397 to 420 nm for **6** and to 443 nm for **7** and **8**, whereas no shift was observed in the spectrum of **9**.

Treatment of **6** with D_2O gave no H–D exchange, but the addition of a catalytic amount of NaOH caused the broad N–H NMR absorption to disappear, and the sharp doublet for H-6 became a sharp singlet. These results indicated **6** to be a single geometric isomer with respect to the C–N bond as was shown for **3**. Compound **7** exchanged the $NHCH_3$ hydrogen in the absence of added base, and both NH hydrogens exchanged in the presence of hydroxide ion. In the latter experiment the signals for H-6 again changed from a sharp doublet to a sharp singlet.

Reaction with Secondary Amines. Treatment of **3** with an excess of piperidine gave **10** in 77% yield. The use of an equimolar quantity of piperidine lowered the yield to 45%. Reaction of **3** with a large excess of the sterically bulky diisopropylamine, however, afforded only a 21% yield of **11** after 3.5 days under reflux (with added ethanol), and essentialy no product was formed at room temperature after 7 days. For both **10** and **11** the NMR absorption for H-6 was a singlet as expected. The longest wavelength UV maximum for **3** at 351 nm was shifted to 361 and 363 nm for **10** and **11**, respectively. Structural assignments for **10** and **11** were based on elemental and spectral analyses.

Experimental Section

All chemicals were reagent grade. Petroleum ether of boiling point 35–65 °C was used unless otherwise specified. Tetrahydrofuran (THF) was distilled from sodium benzophenone ketyl immediately prior to use. Dimethylformamide (DMF) was distilled and then stored over 4-Å molecular sieves. Amines, acetyl chloride, and dimethyl sulfate were distilled from CaH or CaO immediately prior to use. All reactions were run under an argon

(4) Gutowsky, H. S.; Holm, C. H. *J. Chem. Phys.* **1956**, *25*, 1228. Phillips, W. D. *Ibid.* **1955**, *23*, 1363.

(5) We thank Professors L. D. Colebrook and L. D. Hall, who will report the details elsewhere, for performing this experiment. For a description and other applications of the method, cf.: Colebrook, L. D.; Hall, L. D. *Can. J. Chem.* **1980**, *58*, 2016. The predicted relaxation rate order for the *Z* isomer would be H-3 ≃ H-4 > H-5.

or nitrogen atmosphere. Melting points are uncorrected. Those below 180 °C were obtained with sealed capillary tubes on a Thomas-Hoover apparatus, and those above 180 °C were taken on a Mel-Temp apparatus. Spectral data were recorded on the following instruments: UV, Cary Model 14 recording spectrophotometer (1.0-cm quartz cells) with spectral grade hexanes (*n*-hexane–methylcyclopentane mixture) or methanol from Malinckrodt, Inc.; IR, Beckman Model Acculab 4 infrared spectrophotometer (NaCl prisms); ^{1}H NMR, Varian Model EM3604 spectrometer or Varian CFT-20 spectrometer with Me_4Si as an internal standard. Elemental analyses were performed by Galbraith Laboratories, Inc., Knoxville, TN. Analytical TLC plates were coated (~0.2 mm) with Merck 200-mesh silica gel, and preparative TLC plates were coated (2 mm) withMerck 60 F_{254} silica gel. Products were detected by exposure of the dried plates to I_2 or UV light.

2-Acetyl-6-(dimethyamino)fulvene (3). To a stirred solution of sodium cyclopentadienide prepared from 0.72 g (0.03 mol) of NaH and 2.2 g (0.033 mol) of cyclopentadiene was added dropwise 2.59 g (0.033 mol) of acetyl chloride. After 30 min, a solution prepared from 0.76 g (0.033 mol of Na and 15 mL of CH_3OH was added slowly, and the resulting orange-red mixture was stirred for 40 min before the dropwise addition of the cooled, orange reagent formed at steam bath temperature (5 h) from 3.78 g (0.03 mol) of dimethyl sulfate and 2.4 g (0.33 mol) of DMF. After removal of the solvent at 38 °C (reduced pressure), the residue was shaken with 300 mL of ether and 300 mL of H_2O. The separated H_2O layer was extracted with 200-mL portions of ether until the ether layer was colorless. The combined ether solutions were washed with saturated NaCl until the aqueous phase was colorless and then dried (Na_2SO_4). Removal of the solvent (reduced pressure) and recrystallization of the residue from petroleum ether (bp 40–60 °C) gave 2.7 g (55%) of **3** as orange-yellow crystals: mp 62–63 °C (lit.[3] mp 62–63 °C); UV (hexanes) 238 nm (log ϵ 3.94), 351 (4.00); IR ($CHCl_3$) 1630 (C=O), 1600 cm^{-1} (C=C); NMR ($CDCl_3$) δ 2.47 (s, 3, CH_3C=O), 3.3, (s, 3, NCH_3), 3.4 (s, 3, NCH_3), 6.4 (apparent t, 1, H-4, $J_{4,5}$ = 4.2 Hz, $J_{4,3}$ = 4.0 Hz), 6.9 (dd, 1, H-5, $J_{5,3}$ = 2 Hz, $J_{5,4}$ = 4.2 Hz), 7.1 (dd, 1, H-3, $J_{3,4}$ = 4.0 Hz, $J_{3,5}$ = 2.0 Hz), 9.02 (s, 1, H-6).

2-Acetyl-6-(hydroxyamino)fulvene (4). A solution of 0.815 g (5 mmol) of 2-acetyl-6-(dimethylamino)fulvene (**3**), 0.3475 g (5 mmol) of hydroxylammonium chloride, and 4.04 mL (0.05 mol) of pyridine in 30 mL of absolute ethanol under an Ar atmosphere was heated with stirring at 35 °C for 1.5 h at which time a TLC of an aliquot showed no **3** present. The volatile components were removed at 35 °C (reduced pressure), and the residue was shaken with 100 mL of H_2O and a mixture of 25 mL each of petroleum ether and ethyl ether. The separated aqueous layer was extracted with 50-mL portions of 1:1 petroleum ether–ethyl ether until the organic layer was colorless. Removal of the solvents at 30 °C (reduced pressure) from the combined, dried (Na_2SO_4) ether solutions and recrystallization of the crude, greenish yellow residue from petroleum ether gave 0.2338 g (35%) of **4** as yellow crystals: mp 122–123 °C; UV (hexanes) 210 nm (log ϵ 3.64), 250 (3.90), 320 (3.70), 328 (sh, 3.69), 376 (sh, 3.31); IR ($CHCl_3$) 3580 (NH), 3280 (OH), 1630 cm^{-1} (C=O); NMR ($CDCl_3$) δ 2.51 (s, 3, CH_3C=O), 6.42 (apparent t, 1, H-4, $J_{4,5}$ = 4.2 Hz, $J_{4,3}$ = 4.0 Hz), 7.0 (dd, 1, H-5, $J_{5,4}$ = 4.0 Hz, $J_{5,3}$ = 2.0 Hz), 7.20 (dd, 1, H-3, $J_{3,4}$ = 4.0 Hz, $J_{3,5}$ = 2.0 Hz), 8.16 (d, H-6, J = 6 Hz), 15.73 (br d, 1, NH, J = 6 Hz).

Anal. Calcd for $C_8H_9NO_2$: C, 63.56; H, 6.00; N, 9.26. Found: C, 63.53; H, 6.06; N, 9.26.

2-Acetyl-6-[(2-hydroxyethyl)amino]fulvene (5). A solution of 0.245 g (1.5 mmol) of 2-acetyl-6-(dimethylamino)fulvene (**3**) and 0.27 mL (0.276 g, 4.5 mmol) of 2-aminoethanol in 20 mL of THF was stirred at room temperature under an Ar atmosphere for 3 h (negative TLC test for **3**). Removal of the volatile components at 30 °C (reduced pressure) left a yellow oil, most of which dissolved in 5 mL of THF. The insoluble particles were separated (filtration), and petroleum ether was added to the filtrate until a slight clouding formed. Cooling the mixture at −10 °C (ice–salt bath) gave a brownish yellow solid which was recrystallized from THF–petroleum ether (1:30) as yellow crystals of **5**: 0.229 g (85.3%); mp 78–78.5 °C; UV (hexanes) 256 nm (log ϵ 4.42), 235 (4.19), 397 (4.08); IR ($CHCl_3$) 3600 (NH), 3400 (OH), 2940 (CH), 1670 (C=O), 1590 cm^{-1} (C=C); NMR ($CDCl_3$) δ 2.53 (s, 3, CH_3C=O), 3.0 (s, 1, OH), 3.80 (m, 4, CH_2CH_2), 6.41 (apparent t, 1, H-4, $J_{4,3}$ = 4.0 Hz, $J_{4,5}$ = 4.0 Hz), 7.0 (dd, 1, H-5, $J_{5,3}$ = 2.0 Hz, $J_{5,4}$ = 4.0 Hz), 7.4 (dd, 1, H-3, $J_{3,4}$ = 4.0 Hz, $J_{3,5}$ = 2.0 Hz), 7.8 (d, 1, H-6, J = 12 Hz), 12.5 (br, NH).

Anal. Calcd for $C_{10}H_{13}NO_2$: C, 67.02; H, 7.31; N, 7.82. Found: C, 66.80; H, 7.46; N, 7.92.

2-Acetyl-6-(phenylamino)fulvene (6). A solution of 0.245 g (1.5 mmol) of 2-acetyl-6-(dimethylamino)fulvene (**3**) and 0.41 mL (0.419 g, 4.5 mmol) of aniline in 20 mL of THF was stirred at room temperature under an Ar atmosphere for 1 day (TLC test showed trace of **3**). Removal of the volatile components at 35 °C (reduced pressure) left a brownish yellow oil which was chromatographed on a preparative TLC plate with CH_2Cl_2. The first (major) band gave a yellow oil which was taken up in 3 mL of ethanol. Water was added until cloudiness persisted, and the mixture was placed in an ice–salt bath for 10 h. Filtration then separated 0.2125 g (67.1%) of **6** as yellow crystals: mp 83–83.5 °C (after drying under N_2); UV (hexanes) 265 nm (log ϵ, 4.17), 373 (4.02), 420 (4.10); IR ($CHCl_3$), 3690 (NH); 1665 (C=O), 1602 cm^{-1} (C=C); NMR (CCl_4) δ 2.50 (s, 3, CH_3C=O), 6.25 (apparent t, 1, H-4, $J_{4,5}$ = 4.2 Hz, $J_{4,3}$ = 4.0 Hz), 6,83 (dd, 1, H-5, $J_{5,4}$ = 4.2 Hz, $J_{5,3}$ = 2.0 Hz), 7.23 (overlapped m, 1, H-3), 7.33 (m, 5, C_6H_5), 7.92 (d, 1, H-6, J = 12 Hz), 14.31 (br, 1, NH).

Anal. Calcd for $C_{14}H_{13}NO$: C, 79.60; H, 6.20; N, 6.63. Found: C, 79.91; H, 6.41; N, 6.58.

2-Acetyl-6-[[*p*-(methylamino)phenyl]amino]fulvene (7). A solution of 0.1632 g (1.0 mmol) of 2-acetyl-6-(dimethylamino)fulvene (**3**) in 5 mL of THF was added dropwise to a stirred solution of 0.6828 g (3.5 mmol) of *p*-(methylammonio)anilinium dichloride and 3.5 mL of pyridine in 35 mL of EtOH–THF (1:6) under an Ar atmosphere. Stirring was continued at room temperature for 1 day (TLC with 1:2 EtOAc–petroleum ether showed one major, yellow, UV-absorbing spot at R_f 0.65). The mixture was filtered, and the volatile components of the filtrate were removed at 35–50 °C (reduced pressure). Preparative chromatography of the reddish brown solid residue (1:2 EtOAc–petroleum ether) gave three bands, the first being a trace of unidentified product and the third a mixture of **3** and *p*-(methylamino)-phenylamine. Extraction of the second band into THF and removal of the solvent gave an orange solid. Recrystallization from petroleum ether afforded 0.1035 g (43.1%) of **7** as orange crystals: mp 123–124 °C; UV (hexane) 269 nm (log ϵ 3.75), 370 (sh, 3.54), 443 (2.86); IR ($CHCl_3$) 3690 (NH), 3450 (NH), 1665 (C=O), 1600 cm^{-1} (C=C); NMR ($CDCl_3$) δ 2.55 (s, 3, CH_3C=O), 2.73 (s, 3, NCH_3), 3.80 (br, 1, NH), 6.39 (apparent t, 1, H-4, $J_{4,3}$ = 4.0 Hz, $J_{4,5}$ = 4.2 Hz), 6.63 (dd, 1, H-5, $J_{5,3}$ = 2.0 Hz, $J_{5,4}$ = 4.2 Hz), 7.0 (dd, 1, H-3, $J_{3,4}$ = 4.0 Hz, $J_{3,5}$ = 2.0 Hz), 7.12 (m, 2, phenyl), 7.41 (m, 2, phenyl), 7.89 (d, 1, H-6, J = 14 Hz), 14.31 (br, 1, NH).

Anal. Calcd for $C_{15}H_{16}N_2O$: C, 74.97; H, 6.71; N, 11.66. Found: C, 74.86; H, 6.96; N, 11.60.

2-Acetyl-6-[(*o*-aminophenyl)amino]fulvene (8). A solution of 0.1306 g (0.8 mmol) of 2-acetyl-6-(dimethylamino)fulvene (**3**) and 0.2596 g (2.4 mmol) of *o*-aminoaniline in 20 mL of THF was stirred under an Ar atmosphere at room temperature for 1 day (TLC with 1:2 EtOAc–petroleum ether showed one major, yellow, UV-absorbing spot at R_f 0.8). Removal of the volatile components at 35 °C (reduced pressure) left a brown-yellow solid which was chromatographed (preparative plate) with 1:2 EtOAc–petroleum ether. The first and largest of the three colored bands was extracted into THF. Removal of the solvent left an orange solid. Recrystallization from absolute EtOH gave 0.162 g (89.5%) of **8** as reddish orange needles: mp 168–169 °C; UV (hexanes) 222 nm (log ϵ 3.93), 262 (4.12), 370 (sh, 3.76), 443 (5.03); IR ($CHCl_3$) 3480 (NH), 3400 (NH_2), 1665 (C=O), 1610 cm^{-1} (C=C); NMR ($CDCl_3$) δ 2.60 (s, 3, CH_3=O), 4.10 (br, 2, NH_2) 6.42 (apparent t, 1, H-4), $J_{4,5}$ = 4.2 Hz, $J_{4,3}$ = 4.0 Hz), 6.80 (overlapping m, 2, H-5 and H-3), 7.0 (m, 2, phenyl), 8.02 (d, 1, H-6, J = 12 Hz), 14.18 (br, 1, NH).

Anal. Calcd for $C_{14}H_{14}N_2O$: C, 74.31; H, 6.24; N, 12.38. Found: C, 74.12; H, 6.32; N, 12.18.

2-Acetyl-6-(2-phenylhydrazino)fulvene (9). A mixture of 0.1143 g (0.7 mmol) of 2-acetyl-6-(dimethylamino)fulvene (**3**), 0.15 mL (0.1646 g, 1.5 mmol) of phenylhydrazine, and 5 mL of EtOH was stirred at room temperature under an Ar atmosphere for 9 h (TLC with 1:3 EtOAc–petroleum ether negative for **3**). H_2O (10 mL) was added, and the cloudy mixture was stirred (1 min),

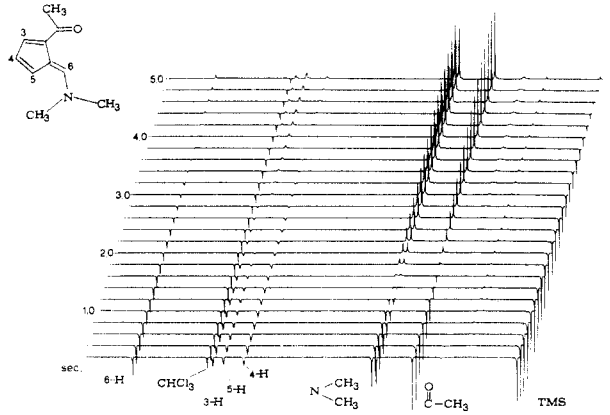


Figure 1. NMR spin-lattice relaxation spectra of 2-acetyl-6-(dimethylamino)fulvene (**3**).[5]

covered, and placed in a freezer (-24 °C) for 1 day. Filtration separated crude **9** which, after recrystallization from EtOH-H_2O, amounted to 0.095 g (65.1%) of **9** as golden yellow crystals: mp 103-104 °C; UV (hexanes) 256 nm (log ϵ 4.07), 336 (3.82), 398 (3.68); IR ($CHCl_3$) 3680 (NH), 3340 (NH), 1659 (C=O), 1590 cm^{-1} (C=C); NMR (acetone-d_6) δ 2.47 (s, 3, CH_3C=O), 6.26 (apparent t, 1, H-4, $J_{4,3}$ = 4.0 Hz, $J_{4,5}$ = 4.2 Hz), 7.10 (m, 7, H-5, H-3, and phenyl), 8.02 (d, 1, H-6, J = 9 Hz), 8.39 (m, 1, NH), 14.22 (br, 1, NH).

Anal. Calcd for $C_{14}H_{14}N_2O$: C, 74.31; H, 6.24; N, 12.38. Found: C, 74.36; H, 6.38; N, 12.30.

2-Acetyl-6-piperidylfulvene (10). A solution of 0.245 g (1.5 mmol) of 2-acetyl-6-(dimethylamino)fulvene (**3**) and 0.45 mL (0.387 g, 4.5 mmol) of piperidine in 20 mL of THF was stirred at room temperature for 2 days (TLC with 10:3 petroleum ether-EtOAc showed one major, yellow, UV-absorbing spot at R_f 0.31). Removal of the volatile components at 35 °C (reduced pressure) and chromatography (preparative TLC with 10:3 petroleum ether-EtOAc) of the brownish yellow oil gave three colored bands. The second band was extracted with THF and the solvent removed (vacuum pump). Recrystallization of the yellow solid residue from petroleum ether and drying under N_2 gave 0.235 g (77.1%) of **10** as yellow needles: mp 84-85 °C; UV (hexanes) 361 nm (log ϵ 4.33), 236 (4.12); IR ($CHCl_3$) 2950 (CH), 1630 C=O), 1602 cm^{-1} (C=C); NMR (CCl_4) δ 1.79 (br s, 6, CH_2), 2.36 (s, 3, CH_3C=O), 372 (br, 4, NCH_2), 6.20 (apparent t, 1, H-5, $J_{5,4}$ = 4.2 Hz, $J_{5,3}$ = 2.0 Hz), 6.89 (dd, 1, H-3, $J_{3,4}$ = 4.0 Hz, $J_{3,5}$ = 2.0 Hz), 8.79 (s, 1, H-6).

Anal. Calcd for $C_{13}H_{17}NO$: C, 76.81; H, 8.43; N, 6.89. Found: C, 76.94; H, 8.50; N, 6.79.

2-Acetyl-6-(diisopropylamino)fulvene (11). A mixture of 0.855 g (0.5 mmol) of 2-acetyl-6-(dimethylamino)fulvene (**3**), 2.1 mL (1.516 g, 1.5 mmol) of diisopropylamine, and 20 mL of absolute EtOH under an atmosphere of Ar was refluxed for 3.5 days (TLC with 4:1 EtOAc-petroleum ether showed spots for **3** at R_f 0.27 and for **11** at R_f 0.77). Removal of the volatile components under reduced pressure and preparative TLC of the brownish yellow residue with 4:1 EtOAc-petroleum ether gave two yellow bands. Extraction of the leading (R_f 0.77) band with THF and removal of the solvent left a yellow solid. Recrystallization from petroleum ether gave 0.0236 g (21.5%) of **11** as yellow crystals: mp 115-116 °C; UV (hexanes) 242 nm (log ϵ 3.99), 363 (4.03); IR ($CHCl_3$) 2920 (CH), 1620 (C=O), 1582 cm^{-1} (C=C); NMR ($CDCl_3$) δ 1.39 (d, 6, $(CH_3)_2C$, J = 6 Hz), 2.50 (s, 3, CH_3C=O), 3.85 (m, 1, Me_2CH), 4.89 (m, 1, Me_2CH), 6.45 (apparent t, 1, H-4, $J_{4,3}$ = 4.0 Hz, $J_{4,5}$ = 4.2 Hz), 6.88 (dd, 1, H-5, $J_{5,4}$ = 4.2 Hz, $J_{5,3}$ = 2.0 Hz), 7.15 (dd, 1, H-5, $J_{5,4}$ = 4.2 Hz, $J_{5,3}$ = 2.0 Hz), 7.15 (dd, 1, H-3, $J_{4,3}$ = 4.0 Hz, $J_{3,5}$ = 2.0 Hz), 9.33 (s, 1, H-6).

Anal. Calcd for $C_{14}H_{21}NO$: C, 76.67; H, 9.65; N, 6.39. Found: C, 76.46; H, 9.85; N, 6.45.

Registry No. (*E*)-**3**, 81158-08-9; **4**, 81158-09-0; **5**, 81158-10-3; **6**, 81158-11-4; **7**, 81158-12-5; **8**, 81158-13-6; **9**, 81158-14-7; **10**, 81158-15-8; **11**, 81158-16-9; hydroxylammonium chloride, 5470-11-1; 2-aminoethanol, 141-43-5; aniline, 62-53-3; *p*-(methylammonio)anilinium dichloride, 5395-70-0; *o*-aminoaniline, 95-54-5; phenylhydrazine, 100-63-0; piperidine, 110-89-4; diisopropylamine, 108-18-9.

Quinone Chemistry. Synthesis of a Masked Naphthazarin Synthon

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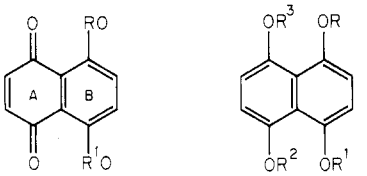
As part of a larger synthetic problem we required a naphthazarin (**1**) based synthon in which the B ring was



1, R = R^1 = H
2, R = R^1 = Me
3, R = H; R^1 = Me
4, R = Ac; R^1 = Me
5, R = Bz; R^1 = Me
6, R = H; R^1 = R^2 = R^3 = Me
7, R = R^2 = R^3 = Ac; R^1 = Me
8, R = Bz; R^1 = Me; R^2 = R^3 = H
9, R = Bz; R^1 = R^3 = Me; R^2 = H
10, R = Bz; R^1 = R^2 = R^3 = Me
11, R = Bz; R^1 = R^2 = Me; R^3 = H

Bz = COC_6H_5

monoprotected and the quinone system masked in such a way to increase the electron density of the B ring and yet permit facile regeneration of the quinone at a later stage of the synthesis. These requirements are fulfilled by the tetrasubstituted naphthalene **6**. In this paper we report the preparation of **6** from naphthazarin (**1**) which features the direct monoalkylation of **1**.

Several groups have reported the methylation of naphthazarin (**1**) with methyl *p*-toluenesulfonate or methyl iodide and silver oxide to afford the dimethyl ether **2** as the principal product.[1-4] The monomethyl ether **3** was reported as a side product in one of these preparations.[3] Subsequent to the beginning of our work a report[5] describing an efficient, albeit multistep, synthesis of a monoalkyl naphthazarin via a sequence involving monoacylation, alkylation, and deacylation appeared.

In our hands the reaction of **1** with methyl iodide and silver oxide in refluxing $CHCl_3$, as monitored by TLC, afforded an initial product more polar than **1** which was slowly consumed to afford a second still more polar product. After consumption of **1** as determined by TLC, the initial product could be isolated in 47% yield and was characterized as the monoethyl ether **3**. The second product, characterized as the dimethyl ether **2**, was also obtained in 10% yield. Upon prolonged reaction, **2** became the major reaction product.

The seemingly anomalous chromatographic mobilities of **1-3** can be explained by the strong intramolecular hydrogen bonds between the peri hydroxyl and carbonyl moieties, preventing the interaction of these polar groups with the absorbent. Methylation disrupts the hydrogen-bonded system, permitting interaction of the ether and

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