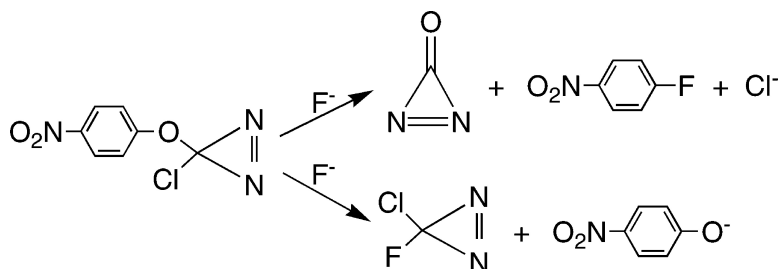


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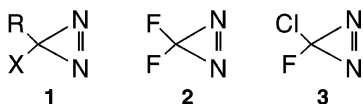
Unprecedented Chemistry of an Aryloxychlorodiazirine: Generation of a Dihalodiazirine and Diazirirone

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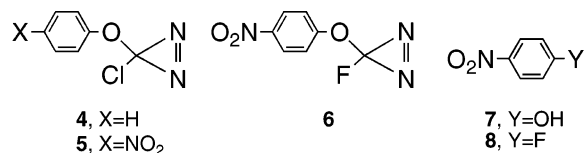
Diazirines are prime precursors of carbenes.¹ For example, archetypal electrophilic (CF₂),² ambiphilic (MeOCCl),³ and nucleophilic (MeOCOMe)⁴ can be generated from appropriate diazirines for spectroscopic and reactivity studies. Halodiazirines **1** are obtained from the hypohalite oxidation of amidines or isouronium salts (Graham oxidation).⁵ Here, R can be alkyl, aryl, vinyl, or alkoxy (aryloxy), while X is Cl or Br.⁵



This extraordinary reaction can be coupled with subsequent nucleophilic exchange of X by, for example, fluoride⁶ or alkoxide⁷ to afford many additional diazirines,¹ including fluoromethoxydiazirine⁸ and dimethoxydiazirine.⁴

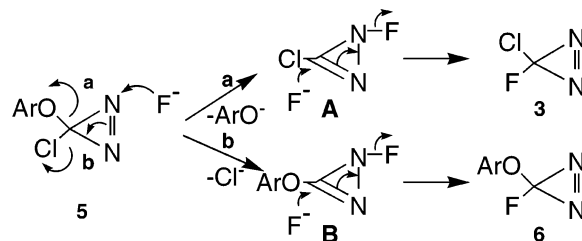
Given the centrality of dihalocarbenes in carbene chemistry,⁹ dihalodiazirines are particularly desirable precursors. Difluorodiazirine (**2**) is available by the reductive defluorination cyclization of perfluoroformamidine^{2d} or bis(difluoroamino)difluoromethane,^{10a,b} and by the CsF-catalyzed, gas-phase isomerization of difluorocyanamide.^{10c} Chlorofluorodiazirine (**3**) can also be obtained by reductive defluorination cyclization.¹¹ However, these preparations all require direct fluorination via intermediates that can be “shatteringly explosive”.¹² Moreover, despite the utility of the two-step Graham oxidation–nucleophilic exchange sequence,^{5–8} dihalodiazirines have not yet been prepared by this method. Here, we demonstrate how this can be done with a novel preparation of **3**, and we describe a remarkable accompanying reaction that, for the first time, generates diazirirone, the diaza analogue of cyclopropanone.

To obtain a dihalodiazirine from **1**, “R” must be converted into a leaving group. Thus, phenoxychlorodiazirine (**4**)¹³ was nitrated with nitronium tetrafluoroborate¹⁴ (0 °C, MeNO₂) to give *p*-nitrophenoxychlorodiazirine (**5**) in 40% yield.¹⁵ Diazirine **5** was characterized spectroscopically: IR, 1530 cm⁻¹ (N=N); UV, λ_{max} 337, 353 nm (pentane), ¹H NMR (δ, CDCl₃), 7.47, 8.33 (A₂B₂ multiplets). Next, diazirine **5** in CD₃CN or CDCl₃ was reacted with “molten” tetrabutylammonium fluoride (TBAF)⁶ at 0–25 °C for 10 h. The product mixture contained three principal components: *p*-nitrophenoxyfluorodiazirine (**6**), *p*-nitrophenol (**7**), and *p*-nitrofluorobenzene (**8**) in the approximate ratio 28:17:55, respectively.

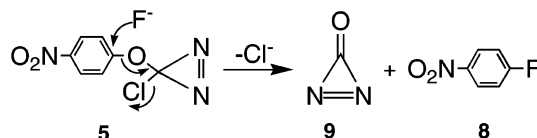


Products **7** and **8** were identified by NMR comparisons to authentic samples, as well as NMR spiking experiments. Fluoro-

Scheme 1



Scheme 2



diazirine **6**, the expected⁶ halide exchange product of chlorodiazirine **5**, was purified by chromatography and characterized spectroscopically: IR, 1525 cm⁻¹ (N=N), UV, λ_{max} 336, 352 nm (pentane); ¹⁹F NMR (δ, CFCl₃, CDCl₃), -119.0; ¹H NMR (δ, CDCl₃), 7.38, 8.26 (A₂B₂ multiplets).¹⁵

Products **6–8** imply that reaction of diazirine **5** with F⁻ follows three competitive pathways, where the first two channels involve alternative double S_N2' mechanisms for the diazirine halide exchange reaction;^{5,16,17} cf., Scheme 1. S_N2' fluoride attack on **5** displaces either *p*-nitrophenoxide (later protonated to **7**, path a), affording isodiazirine intermediate **A**, or it displaces chloride (path b), yielding isodiazirine intermediate **B**. Subsequent S_N2' attacks of fluoride then convert **A** to chlorofluorodiazirine (**3**) and **B** to diazirine **6**.

When the reaction of **5** and TBAF was continuously swept with a nitrogen stream, diazirine **3** could be trapped in 0.5 mL of CDCl₃ at 77 K¹⁵ and characterized spectroscopically: ¹⁹F NMR (δ, CFCl₃, CDCl₃), -105.6; IR, 1562 cm⁻¹ (N=N) [lit.,¹¹ 6.50 μ, 1538 cm⁻¹]; UV, λ_{max} 324, 340, 356 nm (CDCl₃) [lit.,¹¹ 310–360 nm, gas phase]. Photolysis of **3** in CDCl₃ and isobutene (350 nm, sealed tube) gave 1-chloro-1-fluoro-2,2-dimethylcyclopropane^{15,18} (the adduct of ClCF), identified spectroscopically and by comparison to an authentic sample.^{15,19}

The third (and dominant) channel from the reaction of **5** and TBAF is the most unusual; cf., Scheme 2. Reaction of ~0.2 g of molten TBAF with 50 mg of **5** in 0.2 mL of CDCl₃ or 1,2-dichloroethane (DCE) in an IR cell at -10 to -15 °C afforded CO (2117 and 2168 cm⁻¹).²⁰ Immediately after reagent mixing, a strong absorption appeared at 2150 cm⁻¹ and gradually decayed over 3–5 min as the reaction temperature rose toward ambient; simultaneously, CO appeared at 2115 and 2173 cm⁻¹; cf., Figure 1. We attribute the transient IR feature at 2150 cm⁻¹ to diazirirone (diazacyclopropanone), **9**, which subsequently fragments to CO (and N₂).²¹

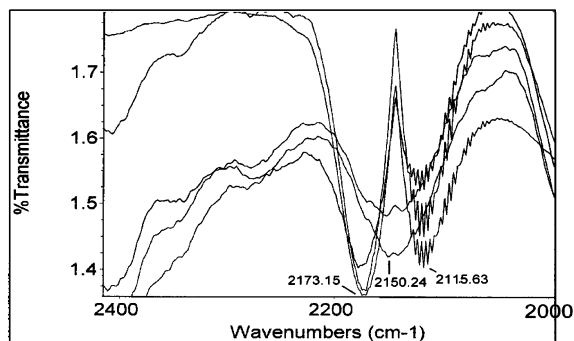


Figure 1. Infrared spectra following reaction of diazirine **5** with TBAF. Diazirinone (**9**) at 2150 cm^{-1} decreases as CO at 2115 and 2173 cm^{-1} increases. Including ~ 2 min of preparation time, the lifetime of **9** in this experiment is ~ 5 min.

Formation of *p*-nitrofluorobenzene **8** from diazirine **5** and TBAF (see above) requires that Cl^- and a N_2CO fragment be liberated. Computational studies in which we attempted to optimize a Meisenheimer complex formed by fluoride addition at the ipso carbon of **5** (see Scheme 2) led to Cl^- , **8**, and diazirinone **9** (i.e., N_2CO).¹⁵ The computations of Korkin et al. find **9** to be the most stable of various N_2CO isomers; for example, it is about 11 kcal/mol more stable than its known linear isomer nitrosyl cyanide ($\text{O}=\text{N}-\text{CN}$).²² The decomposition of **9** to $\text{CO} + \text{N}_2$ is exothermic by >90 kcal/mol,^{22,23} but requires an activation energy of $24^{24}-27^{22,23}$ kcal/mol, so that **9** should be observable, if metastable.

The (unscaled) computed²² IR $\text{C}=\text{O}$ frequency for **9** is 2064 cm^{-1} (B3LYP) or 2079 cm^{-1} (MP 2), reasonable fits to our observed 2150 cm^{-1} . A better fit is $\text{O}=\text{N}-\text{CN}$, with a reported CN absorption at 2170 cm^{-1} (gas phase),²⁵ although it is difficult to envision its direct generation from diazirine **5** and F^- . We prepared $\text{O}=\text{N}-\text{CN}$ from nitrosyl chloride²⁶ and AgCN .²⁷ Reaction of cold (-20°C) $\text{O}=\text{N}-\text{CN}$ in DCE with TBAF in the IR cell led to immediate disappearance of $\text{O}=\text{N}-\text{CN}$ at 2164 cm^{-1} , coupled with the appearance of CO (2116 and 2169 cm^{-1}). $\text{O}=\text{N}-\text{CN}$ is known²⁸ to (gradually) afford CO and N_2 (presumably via prior dissociation to NO and CN radicals),²⁸ but how fluoride catalyzes this conversion is unclear.

Importantly, the reaction of $\text{O}=\text{N}-\text{CN}$ with TBAF (immediate decomposition) differs from that of the product from **5** and TBAF (decomposition over 5–9 min). We conclude that the carrier of the 2150 cm^{-1} IR band from the reaction of **5** and TBAF is diazirinone **9**, which decays to CO and N_2 with a lifetime of 5–9 min at -20 to 25°C (in the presence of TBAF). The formation of **9** in this reaction, and its properties, are in reasonable accord with computational studies.^{15,22–24}

In summary, the reaction of *p*-nitrophenoxychlorodiazirine **5** with TBAF follows three channels: (1) $\sim 17\%$ of *p*-nitrophenoxide/ F^- exchange to chlorofluorodiazirine **3** and *p*-nitrophenol **7**, (2) $\sim 28\%$ of Cl/F exchange to *p*-nitrophenoxyfluorodiazirine **6**, and (3) $\sim 55\%$ of ipso fluoride attack, affording *p*-nitrofluorobenzene **8** and the previously unknown diazirinone **9**.²⁹

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Supporting Information Available: Experimental procedures and computational studies for Scheme 2. This material is available free of charge via the Internet at <http://pubs.acs.org>.

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