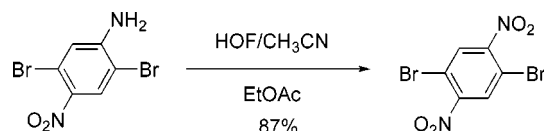


Oxidation of Electron-Deficient Anilines
by HOF. A Route to Nitro-Containing
Compounds for Molecular Electronic
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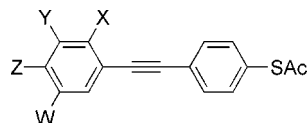
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ABSTRACT



Nitroaromatic compounds for molecular electronic devices are prepared by the high-yielding oxidation of electron-deficient anilines using HOF generated in a fluorine–acetonitrile–water system.

Recent advances in the field of molecular electronics have shown that oligo(phenylene ethynylene)s containing nitro groups are good candidates for electronic switching and storage devices.¹ Using functionalized anilines as an advanced starting point for the synthesis of these molecular systems, we are relying on the oxidation the amine groups to generate the types of nitro compounds (**1–3**) used for molecular electronics.

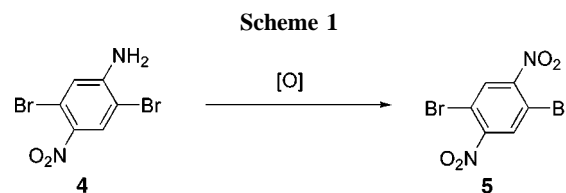


- 1: X, W = NO₂, Y = H, Z = phenylethynyl
 2: X, Y = NO₂, W = H, Z = phenylethynyl
 3: X, W = NO₂, Y = H, Z = phenyl

While oxidation of electron-rich anilines has been studied extensively and many methods exist to accomplish this

transformation,² oxidations of electron-deficient anilines are more difficult to carry out, especially when the compounds also contain alkyne moieties. Efforts to oxidize electron-poor anilines generally involve extremely harsh conditions, which may not be suitable for acetylenic groups.³

Our initial target for oxidation was 2,5-dibromo-4-nitroaniline (**4**) (Scheme 1). Attempts to oxidize this compound



to give **5** using sodium perborate,⁴ or with an in situ generation of dimethyldioxirane,⁵ met with little success.

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[†] Dedicated to Fred Wudl (UCLA) on the occasion of his 60th birthday.

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While 90% H₂O₂ in CF₃COOH⁶ has been used to accomplish similar oxidations, we elected to pursue other avenues before attempting this route.

The formation of HOF from F₂ + H₂O has been studied extensively by Appelman.⁷ Furthermore, the use of HOF/CH₃CN mixtures for the oxidation of organic species, and aromatic amines in particular, has been reported previously.^{8,9} Thus, as an alternative to highly concentrated H₂O₂ oxidations, we chose to use HOF as an oxidizer of our electron-deficient aniline systems.

HOF was generated in situ by bubbling a 20% F₂ in He mixture¹⁰ through 62 mL of a 3% water in acetonitrile mixture maintained at -20 °C. This in situ generation is necessary due to the instability of HOF, even at these low temperatures.⁷ After bubbling the F₂/He mixture through the water/acetonitrile mixture for 2 h at 50 scfm,¹¹ the resulting HOF/acetonitrile mixture was purged with He for several minutes to eliminate any unreacted F₂ (CAUTION).¹² The species to be oxidized (0.8–1.5 mmol) was then added to the HOF/acetonitrile as a solution in either acetone (10 mL) or ethyl acetate (10 mL). The oxidation reaction was allowed to proceed for 5 min at -20 °C before being neutralized by pouring it into saturated aqueous sodium bicarbonate (100–200 mL). Standard workup and characterization followed.

Table 1 shows a comparison of yields for HOF and sodium perborate⁴ reactions. In all cases, the HOF oxidations led to higher yields in much shorter time periods than with the sodium perborate oxidations. Note that the oxidation with sodium perborate typically required 3 days to achieve the yields shown in Table 1. Repeated attempts to oxidize **4** with dimethyldioxirane⁵ were all unsuccessful.

As HOF has turned out to be an excellent oxidizer for these types of electron-deficient aniline systems, we are in the process of trying modified oxidations of related compounds in an effort to streamline our subsequent coupling

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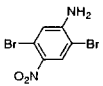
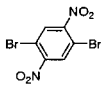
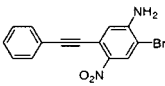
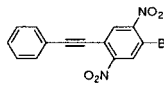
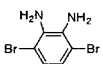
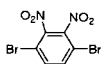
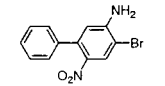
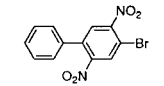
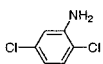
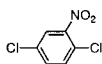
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(10) F₂ is an extremely hazardous gas. Utmost care must be taken when working with this chemical. For safety protocols, we suggest consulting the Matheson Gas Data Book. We have both generated the F₂/He mixtures and purchased them as the mixture from Matheson. The latter procedure is simpler.

(11) Standard cubic centimeter per minute (scfm).

(12) We did experience some explosions early on in our study which we attributed to insufficient purging times. Presumably, unreacted F₂ was reacting violently with our material to be oxidized upon adding the aniline to the HOF/acetonitrile mixture. By purging the reaction vessel for 15 min with 100 scfm of He after the F₂ + H₂O → HOF + HF reaction was complete, our explosion problem ceased.

Table 1. Comparison of HOF to NaBO₃·H₂O Oxidations

entry	reactant	product	HOF yield (%)	NaBO ₃ yield (%)
1			87	80
2			60	51
3			98	
4			99	51
5			97	

strategies. Additionally, since acetate groups have been shown to be inert toward HOF,⁸ we thought it possible that **1–3** could be made by directly oxidizing their aniline counterparts, greatly simplifying our syntheses. Attempts to carry out this oxidation remain elusive, perhaps due to the ease by which the thiol is deprotected. Furthermore, sulfur has been shown to be oxidized by HOF.¹³ HOF oxidations also appear to be incompatible with aryl iodides, as evidenced by our failed attempts to oxidize 4-iodoaniline.

In summary, we have found HOF to be an excellent oxidizer for electron-deficient anilines. Furthermore, this is the first reported example using HOF to oxidize electron-deficient aniline systems containing alkynes. The high yields of oxidized product, coupled with the extremely rapid oxidation rates (relative to other methods in use), make HOF a useful reagent for this purpose.

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Supporting Information Available: ¹H NMR, ¹³C NMR, IR, and mass spectroscopy data for all compounds. This material is available free of charge via the Internet at <http://pubs.acs.org>.

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