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Improved Method for the Iodine(III)-Mediated Preparation of Aryl Sulfonimidates

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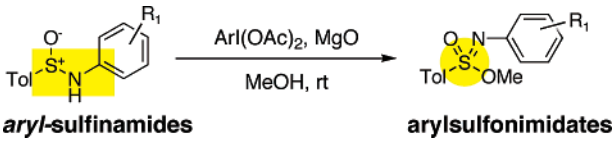
ABSTRACT



***aryl*-sulfinamides** **arylsulfonimidates**

One-pot hypervalent iodine-mediated oxidations of arylsulfinamides to arylsulfonimidates is reported. Contrary to the case of alkylsulfinamides, use of iodosobenzene was not satisfactory. The reaction worked best with diacetoxyiodosobenzene (DIB) and a mild base (MgO). The influence of substituents on the iodine(III) reagent arene has been examined.

Members of the nitrogen-containing sulfur family generally find applications as partners for asymmetric synthesis,[1] ligands,[2] etc. In that context, sulfonimidates are seldom envisaged as relevant candidates despite their use in material science as monomers of polymers with fully inorganic backbones[3] or in asymmetric synthesis.[4] This is probably due to the lack of very practical methods for their preparation. Sulfonimidates have been prepared in a two-step procedure by esterification of alcohols with sulfonimidoyl chlorides.[5] Two routes may be chosen for the synthesis of the active intermediate. The first relies on the rearrangement of sulfonamides mediated by an oxophilic dichlorophosphorane;[6] the second is an oxidative pathway, which starts from sulfinamides.[7] Typical oxidants used are chlorine, *N*-chlorobenzotriazole, or *tert*-butylhypochlorite. A few years ago we reported a one-pot procedure for the preparation of sulfonimidates that did not require the isolation of the intermediate sulfonimidoyl halide.[8] It featured an iodine(III)-mediated oxidation of sulfinamides in the presence of an alcohol. So far the method has been limited to alkylamines. Because aniline derivatives are essential components of natural products, pharmaceutical agents, and agrochemicals, we felt it would be of special interest to extend the scope of our methodology. We report herein the preparation of *N*-aryl sulfonimidates.

(1) Sulfoximines: (a) Johnson, C. R.; Schroeck, C. W. *J. Am. Chem. Soc.* **1973**, *95*, 7418. (b) Gais, H.-J.; Mueller, H.; Bund, J.; Scommoda, M.; Brandt, J.; Raabe, G. *J. Am. Chem. Soc.* **1995**, *117*, 2453. (c) Reggelin, M.; Weinberger, H.; Gerlach, M.; Welcker, R. *J. Am. Chem. Soc.* **1996**, *118*, 4765. (d) For a recent review, see: Reggelin, M.; Zur, C. *Synthesis* **2000**, 1. Sulfinamides: (e) Liu, G.; Cogan, D. A.; Ellman, J. A. *J. Am. Chem. Soc.* **1997**, *119*, 9913. (f) Davis, F. A.; Reddy, R. E.; Szewczyk, J. M.; Reddy, G. V.; Portonovo, P. S.; Zhang, H.; Fanelli, D.; Reddy, T.; Zhou, P.; Carroll, P. J. *J. Org. Chem.* **1997**, *62*, 2555. (g) For a recent review, see: Zhou, P.; Chen, B.-C.; Davis, F. A. *Tetrahedron* **2004**, *60*, 8003. (h) For an alternative approach involving sulfamates, see for example: Espino, C. G.; Wehn, P. M.; Chow, J.; Du Bois, J. *J. Am. Chem. Soc.* **2001**, *123*, 6935.

(2) (a) Bolm, C.; Simic, O. *J. Am. Chem. Soc.* **2001**, *123*, 3830. (b) Harmata, M.; Ghosh, S. K. *Org. Lett.* **2001**, *3*, 3321. (c) For a recent review, see: Okamura, H.; Bolm, C. *Chem. Lett.* **2004**, *33*, 482.

(3) Roy, A. K.; Burns, G. T.; Lie, G. C.; Grigoras, S. *J. Am. Chem. Soc.* **1993**, *115*, 2604.

(4) Reggelin, M.; Junker, B. *Chem. Eur. J.* **2001**, *7*, 1232.

(5) Johnson, C. R.; Jonsson, E. U.; Wambsgans, A. *J. Org. Chem.* **1979**, *44*, 2061.

(6) Roy, A. K. *J. Am. Chem. Soc.* **1993**, *115*, 2598.

(7) (a) Johnson, C. R.; Jonsson, E. U.; Bacon, C. C. *J. Org. Chem.* **1979**, *44*, 2055. (b) Johnson, C. R.; Wambsgans, A. *J. Org. Chem.* **1979**, *44*, 2278.

(8) (a) Leca, D.; Fensterbank, L.; Lacôte, E.; Malacria, M. *Org. Lett.* **2002**, *4*, 4093. (b) Leca, D.; Song, K.; Amatore, M.; Fensterbank, L.; Lacôte, E.; Malacria, M. *Chem. Eur. J.* **2004**, *10*, 906.

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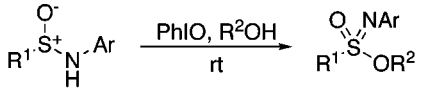
When submitted to iodosobenzene in several different alcohols, *N*-aryl sulfinamides led to the corresponding *N*-aryl sulfonimidates (Table 1). The reactions were generally

Table 1. Iodosobenzene-Mediated Synthesis of *N*-Aryl Sulfonimidates



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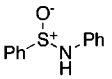
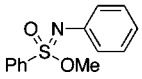
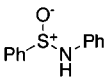
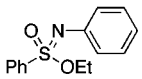
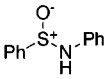
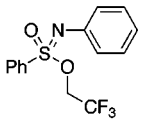
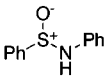
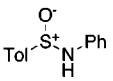
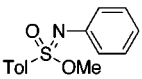
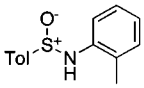
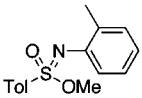
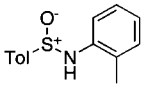
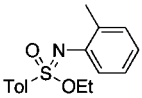
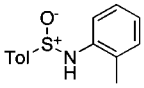
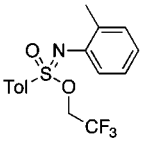
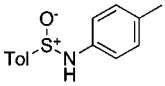
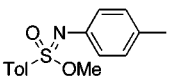
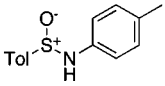
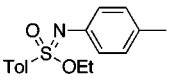
1		MeOH		78
2		EtOH		55
3		TFE		70
4		*i*-PrOH	-[a]	-[a]
5		MeOH		87
6		MeOH		99
7		EtOH		88
8		TFE		58
9		MeOH		43
10		EtOH		52

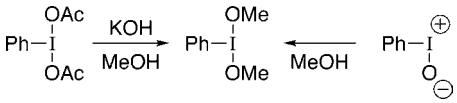
[a] Only degradation occurred.

complete after 1 h. The reaction of *N*-phenyl substrates with primary alcohols was smooth (entries 1, 2, and 5) even when the alcohol was much less nucleophilic, as was the case with TFE (entry 3). The reaction did not work at all when the alcohol was secondary (entry 4). We then decided to use more substituted anilines, keeping in mind that further enriching the aromatic ring might lead to degradation due to the oxidizing power of the hypervalent iodine reagent. We were pleased to see that the reaction still worked for alkyl-substituted anilines (entries 6−10).

However, arylamine derivatives proved to be more problematic than aliphatic ones. The yields strongly vary without understandable trends (compare for example entries 2, 3 and 7, 8), and a given reaction was not easily reproducible. Our hypothesis was that the reactions were strongly dependent on the quality of the iodosobenzene. Although use of freshly prepared reagent helped, this was still not optimal. The outcome still depended strongly on the quality of a rather unstable reagent, whose preparation is tedious. As it cannot be purified easily, we decided to find optimized conditions.

Since both iodosobenzene and $PhI(OAc)_2$/KOH initially lead to the solvolyzed dimethoxy iodosobenzene,[9] our principal rationale for using iodosobenzene rather than the standard $PhI(OAc)_2$/KOH system was to avoid the use of a strong base that could prove harmful to more sensitive organic substrates[8] (Scheme 1).

Scheme 1. Methanolysis of Iodine(III) Derivatives



While looking for his C−H activation system, DuBois showed that MgO was the optimized base for scavenging the acetic acid formed during the solvolysis.[10] We thus decided to go back to the more stable $PhI(OAc)_2$ with this particular base (Table 2).

This proved rewarding as the reactions were much easier and reproducible. They led to the sulfonimidates with consistently higher yields (compare for example Table 1, entries 6−10 to Table 2, entries 1−5).

Upon using those conditions, we could isolate sulfonimidates that could not be prepared through the previous method (entries 7 and 8). Even so, the pyridyl derivative was isolated in poor yield (28%). Oxidation of the same compound with *t*-BuOCl proceeded to the sulfimidoyl chloride with no problem. We speculate that the iodine(III) reagent is more sensitive toward complexation by the pyridine moiety than *t*-BuOCl.

With an improved system in hand, we decided to examine whether the reactions still proceeded with modified diacetoxyiodosoarenes and whether such a change could modulate the reactivity.

For that purpose, we selected three different enriched aryl groups (Figure 1). Because hypervalent iodine atoms are rather electrophilic, we chose electron-enriched aryl moieties. Compound **B** is slightly more congested than compound **A**,

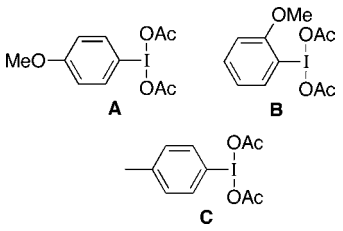
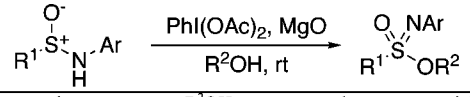
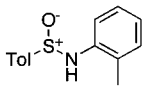
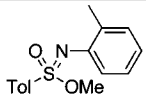
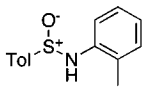
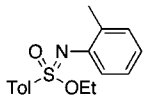
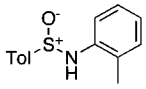
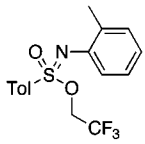
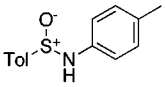
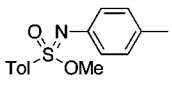
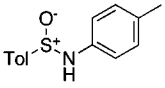
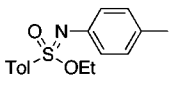
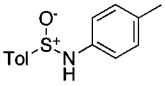
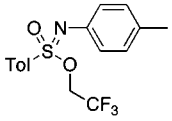
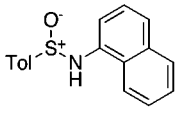
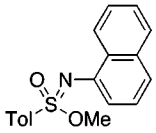
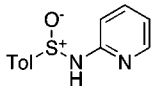
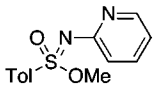


Figure 1. Diacetoxyiodosoarenes used in the oxidation.

Table 2. DIB-Mediated Synthesis of *N*-Aryl Sulfonimidates



entry	substrate	R^2OH	product	yield (%)
1		MeOH		99
2		EtOH		95
3		TFE		71
4		MeOH		93
5		EtOH		74
6		TFE		81
7		MeOH		60
8		MeOH		28[a]

[a] Calculated yield. Product could not be separated from the starting material

Table 3. Oxidation with Modified Diacetoxyiodosoarenes

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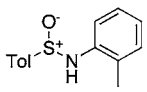
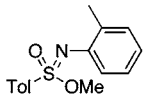
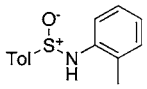
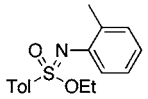
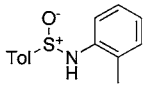
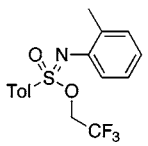
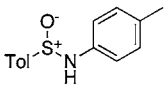
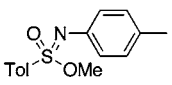
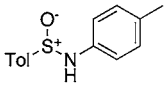
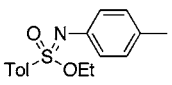
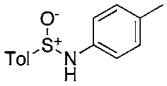
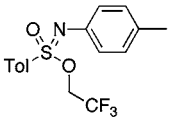
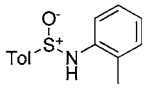
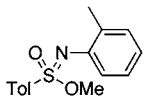
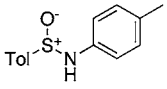
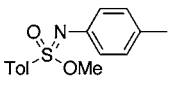
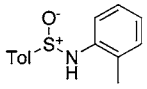
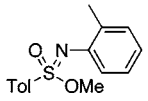
1		A		83
2		A		88
3		A		64
4		A		89
5		A		91
6		A		81
7		B		96
8		B		84
9		C		83

while compound **C** should be intermediate between $PhI(OAc)_2$ and the methoxy-substituted reagents.

In all cases, the reactions afforded the desired arylsulfonimidates in good yields, similar to those reported in Table 2 (Table 3).

In conclusion, we have extended the scope of our methodogy to the one-pot preparation of sulfonimidates from *arylic* sulfinamides. Use of a $PhI(OAc)_2$/MgO system rendered the procedure operationally simpler. It also led to higher yields and is thus much better suited for aniline derivatives. We were also able to extend the reaction to several other diacetoxyiodosoarenes. We are now assessing the limits of our method by starting from more reductive anilines. The stereochemical implications of these new conditions will also be reported in due course.

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Supporting Information Available: Detailed descriptions of the preparation of the *N*-arylsulfonimidates and their characterizations. This material is available free of charge via the Internet at http://pubs.acs.org.

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