

Tennessee State University

Digital Scholarship @ Tennessee State University

Chemistry Faculty Research

Department of Chemistry

12-22-2012

A novel route to organonitrites by Pd-catalyzed cross-coupling of sodium nitrite and potassium organotrifluoroborates

Mohammad Al-Masum
Tennessee State University

Nabil Saleh
Tennessee State University

Tasfia Islam
Tennessee State University

Follow this and additional works at: <https://digitalscholarship.tnstate.edu/chemistry-faculty>

 Part of the [Chemistry Commons](#)

Recommended Citation

Mohammad Al-Masum, Nabil Saleh, Tasfia Islam, "A novel route to organonitrites by Pd-catalyzed cross-coupling of sodium nitrite and potassium organotrifluoroborates", *Tetrahedron Letters*, Volume 54, Issue 9, 2013, Pages 1141-1144, ISSN 0040-4039, <https://doi.org/10.1016/j.tetlet.2012.12.047>.

This Article is brought to you for free and open access by the Department of Chemistry at Digital Scholarship @ Tennessee State University. It has been accepted for inclusion in Chemistry Faculty Research by an authorized administrator of Digital Scholarship @ Tennessee State University. For more information, please contact XGE@Tnstate.edu.

Published in final edited form as:

Tetrahedron Lett. 2013 February 1; 54(9): 1141–1144. doi:10.1016/j.tetlet.2012.12.047.

A novel route to organonitrites by Pd-catalyzed cross-coupling of sodium nitrite and potassium organotrifluoroborates

Mohammad Al-Masum^{*}, Nabil Saleh, and Tasfia Islam

Department of Chemistry, Tennessee State University, 3500 John A. Merritt Blvd., Nashville, TN 37209, United States

Abstract

Microwave irradiated palladium-catalyzed cross-coupling reaction of potassium styryltrifluoroborates and sodium nitrite gives the corresponding styryl nitrites in high yields. Potassium aryltrifluoroborates also furnish aryl nitrites under same reaction condition. This unprecedented cross-coupling is an interesting development and has the potential to lead to new nitration protocols.

Keywords

Sodium nitrite in cross-coupling; Organotrifluoroborates; Organonitrites; Microwave

Potassium organotrifluoroborates are air- and water-stable unique solid compounds. Their use in organic transformations is increasing dramatically.¹ Organonitro compounds, especially, aromatic nitro compounds are important moieties in various pharmaceuticals, dyes, and materials. Instead of using strong acid conditions (HNO₃/H₂SO₄) for nitration which is often poor regioselective, our efforts in developing organonitrite by cross-coupling reaction are exciting and creative. Buchwald's recent report on Pd-catalyzed conversion of aryl chlorides to nitroaromatics^{2a} and Saito's report on Cu-catalyzed coupling of aryl iodides to nitroaromatics^{2b} are pioneering works of cross-coupling chemistry involving potassium and sodium nitrite as coupling partners. Our recent success in constructing direct arylation reaction by the Pd-catalyzed cross-coupling reactions of potassium organotrifluoroborates with aryl halides has motivated us to involve in another new form of cross-coupling reaction of metal nitrite with potassium organotrifluoroborates.³ In this work, we report microwave irradiated palladium catalyzed new reaction for the cross-coupling of organotrifluoroborates with sodium nitrite.

This is an interesting development that has potential to lead a new nitration protocol inspiring to the conventional chemistry. Recently, we have applied several Pd-complexes as catalyst for cross-coupling chemistry involving potassium organotrifluoroborates. One of them is PdCl₂(d'bpf)₂ complex and is very effective. To extend further application of this

Pd-complex, we scanned it along with many bases and solvents for the cross-coupling of styryltrifluoroborates and sodium nitrite. Key activities compared the effects of bases and solvents on the formation of aromatic nitro compounds to optimize the reaction condition. The short lists are shown in Table 1. The reaction mixture of styryltrifluoroborate, sodium nitrite, $\text{NaH}_2\text{PO}_4 \cdot \text{H}_2\text{O}$, and Pd-complex in toluene is largely in an insoluble state. Since the reaction product was detected relatively clear in toluene, we focused in increasing the solubility of the heterogeneous mixture by adding more toluene and found better results. The optimized condition is shown in Scheme 1. A good number of styryltrifluoroborates were synthesized in the laboratory and used with sodium nitrite for cross-coupling reaction and listed in Figure 1. Styrylnitrite **3a** from the cross-coupling of potassium styryltrifluoroborate **1a** and sodium nitrite **2** is shown as a representative procedure. 0.25 mmol of styryltrifluoroborate **1a**, 69.0 mg (1.0 mmol) of NaNO_2 **2**, and 138.0 mg (1.0 mmol) of $\text{NaH}_2\text{PO}_4 \cdot \text{H}_2\text{O}$ were taken into a microwave reaction vial followed by placing the septum cap. The argon was flushed through the reaction vial by piercing a needle into the septum. The cap was unbolted and 3.0 mg (0.0075 mmol) of $\text{PdCl}_2(\text{d}^t\text{bpf})_2$ catalyst was transferred into the reaction vial very quickly and the cap was placed back. The ready to use reaction vial was flushed with argon again for a few seconds. While the toluene bottle was still under argon pressure 5.0 mL of the toluene was added into the reaction mixture via oven dry syringe. The reaction vial was positioned in a microwave device (maximum power setting 250 W) and heated at 120 °C for 30 min. After the reaction is complete, the brown organic layer was pipetted. The remaining solid in the reaction vial was washed with ethyl acetate three times, pipetted, and collected with brown organic layer in a round bottom flask. A small amount of silica gel was added to the round bottom flask. Then the solvent was evaporated. The silica adsorbed reaction product was subjected to silica gel chromatography using combiflash liquid cartridge for purification.

In the case of 4-fluorostyryltrifluoroborate, **1b** and 4-trifluoromethylstyryltrifluoroborates, **1d** yields of the corresponding styrylnitrites **3b** and **3d** were moderate due to the homocoupling products as side products. In all other cases, a trace amount of homocoupling products was also observed. We explored the formation of aryl nitrites by using aryltrifluoroborates and sodium nitrite under the same reaction conditions. It worked but isolated yields were poor (Fig. 2). 4-Chloro-phenyltrifluoroborate **4c** and 4-pyridinyltrifluoroborate **4e** gave undefined complex mixture instead of the corresponding cross-coupling aryl nitrites. 4-trifluoromethylphenyltrifluoroborate **4d** gave the homocoupling product **6** as the major product.

An anion–anion coupling reaction looks like an entirely impossible organic reaction. Most remarkably, however, the Nakamura group⁴ and the Normant group⁵ have proved that the reaction becomes not only experimentally feasible but highly efficient, when magnesium(II) and zinc(II) atoms are used as counteranions. Recent developments by Buchwald,^{2a} Saito,^{2b} and Yamamoto^{2c,d} have provided new directions of the organic transformation.

This dimetallic reaction has a potential value as a quick method to construct a library of various organic derivatives. In this work we provided a new source of making such dimetallic species by Pd-catalyzed cross-coupling of potassium organotrifluoroborates and

sodium nitrite (Scheme 2). To further explore the scope of this cogent technology, many new reactions are underway for investigation in our laboratory.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Financial support from US Department of Education Title III Grant, Tennessee State University is thankfully acknowledged. Tasfia Islam also gratefully acknowledges the receipt of a MARC fellowship from NIH's MARC program.

References and notes

- (a) Molander GA, Ham J. *Org. Lett.* 2006; 8:2031. [PubMed: 16671774] (b) Molander GA, Figueroa R. *Aldrichchim. Acta.* 2005; 38:49.(c) Molander GA, Ellis N. *Acc. Chem. Res.* 2007; 40:275. [PubMed: 17256882] (d) Darses S, Genet J-P. *Chem. Rev.* 2008; 108:288. [PubMed: 18095714]
- (a) Fors BP, Buchwald SL. *J. Am. Chem. Soc.* 2009; 131:12898. [PubMed: 19737014] (b) Saito S, Koizumi Y. *Tetrahedron Lett.* 2005; 46:4715.(c) Yamamoto Y, Al-Masum M, Fujiwara N. *J. Chem. Soc., Chem. Commun.* 1996; 381(d) Yamamoto Y, Fujiwara N. *J. Chem. Soc., Chem. Commun.* 1995:2013.
- (a) Al-Masum M, Liu K-Y. *Tetrahedron Lett.* 2011; 52:5090.(b) Al-Masum M, Ng E, Wai MC. *Tetrahedron Lett.* 2011; 52:1008.(c) Urawa Y, Ogura K. *Tetrahedron Lett.* 2003; 44:271.(d) Kabalka GW, Al-Masum M. *Org Lett.* 2006; 8:11. [PubMed: 16381555] (e) Kabalka GW, Dadush E, Al-Masum M. *Tetrahedron Lett.* 2006; 47:7459.(f) Kabalka GW, Al-Masum M, Mereddy AR, Dadush E. *Tetrahedron Lett.* 2006; 47:1133.(g) Arvela RK, Leadbeater NE, Mack TL, Kormos CM. *Tetrahedron Lett.* 2006; 47:217.(h) Kabalka GW, Al-Masum M. *Tetrahedron Lett.* 2005; 46:6329.(i) Labadie JW, Stille JK. *J. Am. Chem. Soc.* 1983; 105:6129.(j) Milstein D, Stille JK. *J. Am. Chem. Soc.* 1978; 100:3636.(k) Sebelius S, Olsson VJ, Wallner OA, Szabo KJ. *J. Am. Chem. Soc.* 2006; 128:8150. [PubMed: 16787075] (l) Yamamoto Y, Takada S, Miyaura N. *Chem. Lett.* 2006; 35:704.(m) Al-Masum M, Alam S. *Tetrahedron Lett.* 2009; 50:5201.
- (a) Hirai A, Nakamura M, Nakamura E. *J. Am. Chem. Soc.* 1999; 121:8665.(b) Nakamura E, Kubota K, Sakata G. *J. Am. Chem. Soc.* 1997; 119:5457.
- Marek I, Normant J-F. *Chem. Rev.* 1996; 96:3241. [PubMed: 11848859]

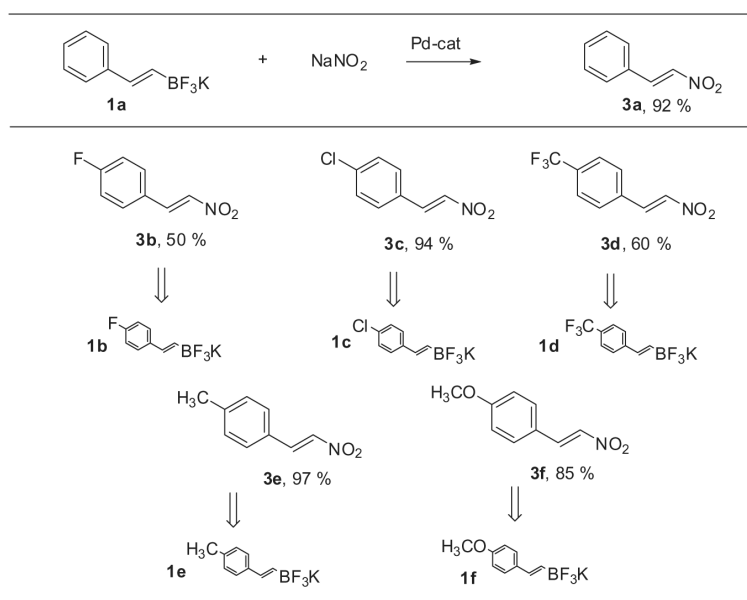


Figure 1. Stylnitrites from cross-coupling of stylyltrifluoroborates and sodium nitrite.^a

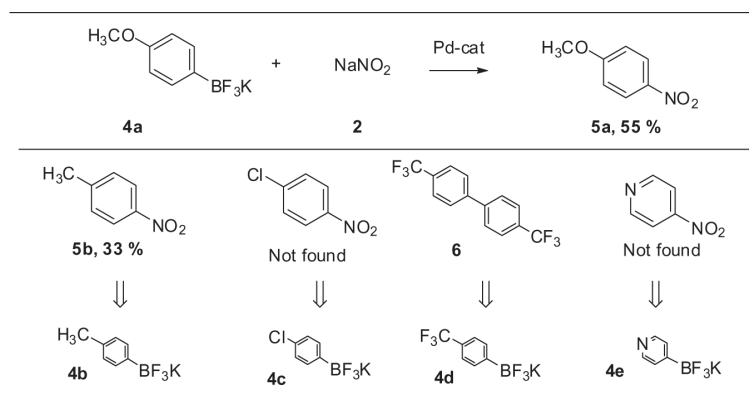
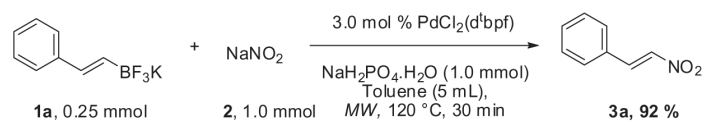


Figure 2.
Arylnitrites from aryltrifluoroborates and sodium nitrite.^a



Method	Amount of Toluene	Nitro Product , 3a
1	1 mL	None
2	2 mL	low yield ^a
3	3 mL	low yield ^a
4	4 mL	25 %
5	5 mL	Major ^b

Scheme 1.
Optimized condition.

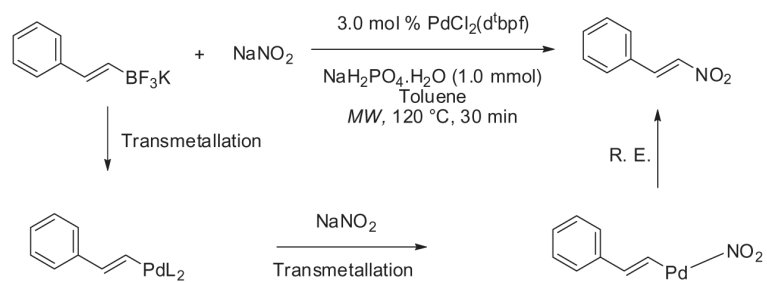
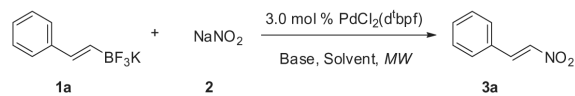
**Scheme 2.**

Table 1Effects of solvents and bases^a

Run	Base 4.0 equiv	Solvent 2.0 mL	MW heating	Nitro product 3a
1	K ₂ CO ₃	1,4-Dioxane	140 °C, 40 min	None
2		DMF	140 °C	Trace amount ^b
3		IPA	120 °C	None
4		THF	100 °C	None
5		Toluene	120 °C	None
6		H ₂ O	120 °C	None
7	NaH ₂ PO ₄ ·H ₂ O	1,4-Dioxane	140 °C	None
8		DMF	140 °C	None
9		IPA	120 °C	None
10		THF	100 °C	None
11		Toluene	120 °C	Styrylnitrate ^c
12		H ₂ O	120 °C	None

^aRatio of **1** and **2** is 1:4.^bMajor product was homocoupling diene (PhCH=CH-CH=CHPh).^cClear new peak of cross-coupling nitro product was observed by GC-MS.