This article was downloaded by: [Duke University Libraries] On: 26 December 2014, At: 22:17 Publisher: Taylor & Francis Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



Synthetic Communications: An International Journal for Rapid Communication of Synthetic Organic Chemistry

Publication details, including instructions for authors and subscription information:

http://www.tandfonline.com/loi/lsyc20

One-Pot Solvent-Free Preparation of 2-Phenyl-1,3,2-aryldioxaborins on Acidic Alumina

M. Reza Naimi-Jamal^a, Mojtaba Mirzaei^b, M. Bolourtchian^b & Ali Sharifi^b ^a Organic Research Laboratory, Faculty of Chemistry, Iran University of Science and Technology, Narmak, Tehran, Iran

^b Chemistry and Chemical Engineering Research Center of Iran, Tehran, Iran Published online: 16 Feb 2007.

To cite this article: M. Reza Naimi-Jamal, Mojtaba Mirzaei, M. Bolourtchian & Ali Sharifi (2006) One-Pot Solvent-Free Preparation of 2-Phenyl-1,3,2-aryldioxaborins on Acidic Alumina, Synthetic Communications: An International Journal for Rapid Communication of Synthetic Organic Chemistry, 36:18, 2711-2717, DOI: 10.1080/00397910600764741

To link to this article: http://dx.doi.org/10.1080/00397910600764741

PLEASE SCROLL DOWN FOR ARTICLE

Taylor & Francis makes every effort to ensure the accuracy of all the information (the "Content") contained in the publications on our platform. However, Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information. Taylor and Francis shall not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, and other liabilities whatsoever or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the Content.

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden. Terms & Conditions of access and use can be found at http://www.tandfonline.com/page/terms-and-conditions

Synthetic Communications[®], 36: 2711–2717, 2006 Copyright © Taylor & Francis Group, LLC ISSN 0039-7911 print/1532-2432 online DOI: 10.1080/00397910600764741



One-Pot Solvent-Free Preparation of 2-Phenyl-1,3,2-aryldioxaborins on Acidic Alumina

M. Reza Naimi-Jamal

Organic Research Laboratory, Faculty of Chemistry, Iran University of Science and Technology, Narmak, Tehran, Iran

Mojtaba Mirzaei, M. Bolourtchian, and Ali Sharifi

Chemistry and Chemical Engineering Research Center of Iran, Tehran, Iran

Abstract: One-pot, solvent-free, microwave-promoted preparation of 1,3,2-aryldioxaborines on the surface of acidic alumina is described.

Keywords: Alumina, boronic acid, microwave irradiation, phenols, solvent-free synthesis

INTRODUCTION

The 2-phenyl-1,3,2,-aryldioxaborins (4) have been found to be very useful and versatile synthetic intermediatens to prepare saligenol derivatives. Although direct derivatization of a phenol with an aldehyde is not *ortho*-specific and results usually in a mixture of *ortho*-, *para*-, and poly substitution, 4 can be readily oxidized to the corresponding α -hydroxyalkylphenols.^[1] It can be also reduced to *o*-alkylphenols or transformed to alkylthiomethylphenol and alkoxymethylphenol derivatives (Scheme 1).^[2] Chambers et al. have reported the successful use of this substance as a stable precursor of quinine

Received in Poland February 3, 2006

Address correspondence to M. Reza Naimi-Jamal, Organic Research Laboratory, Faculty of Chemistry, Iran University of Science and Technology, Narmak, 16846 Tehran, Iran. E-mail: naimi@iust.ac.ir



Scheme 1.

methides in inter- and intramolecular cycloaddition reactions under pyrolytic conditions.^[3]

The general procedure for the preparation of **4** includes refluxing a mixture of a phenol, phenylboronic acid, and an aldehyde in benzene or toluene with azeotropic removal of water using a Dean–Stark trap.^[1,2] The presence of catalytic amounts of a carboxylic acid, such as acetic or propionic acid, is crucial for the reaction to take place. Less reactive reactants need stronger acidic catalysts, such as trichloroacetic acid, for the completion of the reaction.^[1] Another method for the synthesis of **4** is cyclic esterification of boronic acids with suitably constituted diols; however, this method needs the preparation of the corresponding diols, which makes this method a lengthy and unattractive one.^[4]

With regards to the environmental damages caused by employing organic solvents in chemical processes, there is a huge interest in using solvent-free reactions.^[5] Efforts for complete elimination of organic solvents by carrying out organic reactions on the surface of solid supports have been extensively documented.^[6] Active surfaces of solid supports, such as montmorillonite,^[7] clayfen,^[8] and alumina,^[9] serve as suitable alternatives for the organic solvents. The role of solid surfaces is not just limited of being good reaction media; in most cases they catalyze different kinds of organic reactions, too. Therefore, for the reactions taking place on the solid media, vigorous conditions are unnecessary in most cases. In this way, selectivity of the reactions increases, and the amount of unwanted by-products in the course of reactions decreases. Alumina, among other solid supports, seems to be a very interesting reagent, as it can be modified in a variety of ways that enhance its application as acidic or basic catalyst.^[9a] These reactions are usually promoted by microwave irradiation, which reduces the reaction times from several hours to just a few minutes.^[10]



In continuation of our interest in developing solvent-free methods for the preparation of organic compounds,^[11] we report here a solventless, one-pot, three-component preparation of 2-phenyl-1,3,2,-aryldioxaborins **4**, on the surface of acidic Al_2O_3 without using of organic solvents (Scheme 2).

RESULTS AND DISCUSSION

In this procedure, phenol, benzaldehyde, phenylboronic acid, and acidic alumina were mixed, ground together, and irradiated in a microwave oven. Monitoring of the reaction progress by thin layer chromatography (TLC) revealed the formation of a new substance, which was later confirmed to be 4a. After 15 min of irradiation, the yield of the product was 75%, which is by far higher than the conventional preparation method reported by Nagata et al. (49%) in which a benzene solution of reactants with up to seven times excess amounts of aldehyde must be refluxed for 20 h.^[1] Because acidic alumina serves also as the catalyst, the use of an additional carboxylic acid, such as propionic or trichloroacetic acid is unnecessary. On the other hand, heating of the same reaction mixture (ground reactants with acidic alumina) in a regular oven at 80 °C for up to 24 h yields only 11% of the corresponding product. The method tolerates different aromatic and aliphatic aldehydes as well as naphtols and substituted phenols (Table 1). For instance, the reaction of β -naphtol (1b), 1-octanal (2d), and phenylboronic acid (3) affords 4d with 70% yield in 10 min. Paraformaldehyde or formalin both can be used as a formaldehyde source for this reaction.

The advantages of the solid support preparation of **4** compared to the conventional solvent-based method can be summarized as follows: 1) higher yields (65-95%); 2) dramatically shorter reaction times (2-20 min, instead of several hours); 3) elimination of toxic solvents, such as benzene or toluene; and 4) elimination of huge excess amounts of aldehydes and carboxylic acids as catalysts.

In summery, acidic alumina combined with microwave irradiation is an efficient method for a one-pot, three-component preparation of 1,3,2-

| Entry | Phenol | Aldehyde | Product ^a | Time (min) | Yield (%) |
|-------|-------------------|---|------------------------|---------------|--------------|
| 1 | 1a , R = H | 2a, R' = Ph | 4 a | 15 | 75 |
| 2 | 1 a | $\mathbf{2b}, \mathbf{R}' = \mathbf{H}$ | 4 b | 10 | 86 |
| 3 | 1 a | 2c , $\mathbf{R}' = p$ -NO ₂ Ph | 4 c | 20 | 72 |
| 4 | ОН | C ₇ H ₁₅ CHO 2d | 4d | 10 | 70 |
| _ | 1b ~ ~ | | | | |
| 5 | 1b | 2b | 4e | 4 | 90 |
| 6 | 1b | 2c | $4\mathbf{f}^{b}$ | 10 | 85 |
| 7 | 1b | 2a | $4\mathbf{g}^{b}$ | 15 | 65 |
| 8 | OH | 2b | 4h | 15 | 77 |
| 9 | | 2b | 4i | 15 | 88 |
| 10 | | 2c | 4j ^{<i>b</i>} | 8 | 86 |
| 11 | 1e | 2b | 4k | 2 | 95 |

Table 1. Synthesis of 1,3,2-aryldioxaborins on acidic alumina

^{*a*}The structures of the all known products were characterized with comparison of their melting points, or ¹H NMR, with those in the literature.

^bFor new compounds **4f**, **4g**, and **4j**, all spectral data are reported.

aryldioxaborins in a short period of time and in an environmentally friendly, solvent-free method.

EXPERIMENTAL

Melting points were determined on a hot stage or oil bath apparatus without correction. ¹H NMR (80 MHz or 300 MHz) and ¹³C NMR (75 MHz) spectra were recorded on a Bruker 80-MHz or Bruker WP 300-MHz in CDCl₃ using TMS as internal standard. High resolution mass spectrometry (HRMS) was obtained on a Finnigan MAT system MAT 212.

2-Phenyl-1,3,2-aryldioxaborins

General Procedure for the Preparation of 2-Phenyl-1,3,2aryldioxaborins Promoted by Microwave Oven

Phenol (1 mmol), aldehyde (1.2 mmol), phenylboronic acid (1.2 mmol), and acidic alumina (1 g) were carefully mixed and ground together in a mortar. The mixture was transferred to a 25-mL flask and irradiated in a microwave oven for the given time. The progress of reaction was monitored by TLC and GC. After cooling to room temperature, the reaction mixture was washed with ether and filtered, and the solvent was evaporated on a rotary evaporator. The crude product was purified by crystallization (dichloromethane/petrol 1:2). The structures of the all known products were being characterized with comparison of their melting points, or ¹H NMR, with those in the literature. For new compounds **4f**, **4g**, and **4j**, all spectral data are reported.

Data

4f. Mp: 178–180 °C. ¹H NMR (CDCl₃): $\delta = 6.87$ (s, 1H), 7.30–7.60 (m, 8H_{arom}), 7.90–8.20 (m, 7H_{arom}). ¹³C NMR (CDCl₃): $\delta = 72.2$, 115.1, 119.3, 122.0, 124.2 (2C), 124.7, 127.4, 127.8 (2C), 128.6, 128.9, 129.8, 130.5, 130.7, 131.9, 134.5 (2C), 147.2, 147.8, 148.5. MS (EI): m/z = 259.1 (100), 381.1 (60) [M⁺]. HRMS (EI): m/e calcd. for C₂₃H₁₆BNO₄: 381.1172; found: 381.1171.

4g. Mp: 144–146 °C. ¹H NMR (CDCl₃): $\delta = 6.80$ (s, 1H), 7.10–7.15 (m, 2H_{arom}), 7.20–7.60 (m, 10H_{arom}), 7.70–7.90 (m, 3H_{arom}), 7.95-8.10 (d, 1H_{arom}). ¹³C NMR (CDCl₃): $\delta = 73.4$, 109.5, 119.2, 122.6, 124.3, 127.7 (2C), 128.4 (2C), 128.6, 128.8 (2C), 129.0, 129.8, 130.0, 130.1, 131.5, 134.5 (2C), 142.0, 147.1, 153.0. MS (EI): m/e = 259.1 (100), 336.1 (68) [M⁺]. HRMS (EI): m/z calcd. for C₂₃H₁₇BO₂: 336.1322; found: 336.1320.

4j. Mp: 173–175 °C. ¹H NMR (CDCl₃): $\delta = 6.48$ (s, 1H), 6.95 (d, 1H_{arom}), 7.40–7.70 (m, 8H_{arom}), 7.80 (d, 1H_{arom}), 8.10–8.30 (m, 4H_{arom}), 8.55 (d, 1H_{arom}). ¹³C NMR (CDCl₃): $\delta = 74.6$, 117.6, 121.8, 123.1, 123.2, 124.1 (2C), 125.1, 126.6, 127.2, 127.7, 127.9 (2C), 128.3 (2C), 132.0, 134.2, 134.6 (2C), 143.8, 147.9, 149.2. MS (EI): m/e = 259.1 (100), 381.1 (94) [M⁺]. HRMS (EI): m/z calcd. for C₂₃H₁₆BNO₄: 381.1172; found: 381.1173.

REFERENCES

1. Nagata, W.; Okada, K.; Aoki, T. *Ortho*-specific α -hydroxylation of phenols with aldehydes: An efficient synthesis of saligenol derivatives. *Synthesis* **1979**, 365–368.

- Lau, C. K.; Williams, H. W. R.; Tardiff, S.; Dufresne, C.; Scheigetz, J.; Belanger, P. C. Ortho-specific alkylation of phenols via 1,3,2-benzodioxaborines. *Can. J. Chem.* 1989, 67, 1384–1387.
- Chambers, J. D.; Crawford, J.; Williams, H. W. R.; Dufresne, C.; Scheigetz, J.; Bernstein, M. A.; Lau, C. K. Reactions of 2-phenyl-4H-1,3,2-benzodioxaborin, a stable *ortho*-quinone methide precursor. *Can. J. Chem.* **1992**, *70*, 1717–1732.
- (a) Brooks, C. J. W.; Watson, J. Characterization of 1,2- and 1,3-diols by gas chromatography-mass spectrometry of cyclic boronate esters. *Chem. Commun.* **1967**, 952–953; (b) Cragg, R. H.; Nazery, M. Organoboron compounds part VII: Boron derivatives of hydroxyl benzyl alcohol. *J. Chem. Soc., Dalton Trans.* **1974**, 162–165; (c) Kuivila, H. G.; Keough, A. H.; Soboczensky, E. J. Areneboronates from diols and polyols. *J. Org Chem.* **1954**, *19*, 780–783.
- (a) Kaupp, G.; Naimi-Jamal, M. R. Quantitative cascade condensations between o-phenylenediamines and 1,2-dicarbonyl compounds without production of wastes. *Eur. J. Org. Chem.* 2002, *8*, 1368–1373; (b) Kaupp, G.; Naimi-Jamal, M. R.; Schmeyers, J. Solvent-free Knoevenagel condensations and Michael additions in the solid state and in the melt with quantitative yield. *Tetrahedron* 2003, *59*, 3753–3760; (c) Kaupp, G.; Naimi-Jamal, M. R.; Stepanenko, V. A waste-free and facile solid-state protection of diamines, anthranilic acid, diols, and polyols with phenylboronic acid. *Chem. Eur. J.* 2003, *9*, 4156–4160.
- (a) Tanaka, K. Solvent-Free Organic Synthesis. Wiley-VCH: Weinheim, 2003;
 (b) Villa, C.; Mariani, E.; Loupy, A.; Grippo, C.; Grossia, G. C.; Bargagn, A. Solvent-free reactions as green chemistry procedures for the synthesis of cosmetic fatty esters. *Green Chem.* 2003, *5*, 623–626; (c) Varma, R. S. Solvent-free organic syntheses using supported reagents and microwave irradiation. *Green Chem.* 1999, 43–55.
- (a) Srinivas, K. V. N. S.; Das, B. A highly convenient, efficient and selective process for preparation of esters and amides from carboxylic acids using Fe³⁺-K-10 montmorillonite clay. *J. Org. Chem.* 2003, *68* (3), 1165–1167; (b) Chakraborti, A. K.; Kondaskar, A.; Rudrawar, S. Scope and limitations of montmorillonite K 10 catalysed opening of epoxide rings by amines. *Tetrahedron* 2004, 9085–9091; (c) Yadav, J. S.; Reddy, B. V. S.; Satheesh, G. Montmorillonite clay catalyzed alkylation of pyrroles and indoles with cyclic hemi-acetals. *Tetrahedron Lett.* 2004, *45* (18), 3673–3676.
- Varma, R. S.; Dahiya, R. Microwave thermolysis with clayfen: Solvent-free oxidation of sulfides to sulfoxides. *Synth. Commun.* 1998, 28, 4087–4095.
- (a) Kabalka, G. W.; Pagni, R. M. Organic reactions on alumina. *Tetrahedron* 1991, 53, 7999–8065; (b) Estrine, B.; Soler, R.; Damez, C.; Bouquillon, C.; Hénin, F.; Muzart, J. Recycling in telomerization of butadiene with methanol and phenol: Pd-KF/Al₂O₃ as an active heterogeneous catalyst system. *Green Chem.* 2003, 5, 686–689.
- 10. Kappe, C. O. Controlled microwave heating in modern organic synthesis. *Angew. Chem. Int. Ed.* **2004**, *43*, 6250–6284.
- (a) Sharifi, A.; Mohsenzadeh, F.; Naimi-Jamal, M. R. Solvent-free preparation of monoacylaminals assisted by microwave irradiation. *J. Chem. Res. Synop.* 2000, 394–396; (b) Sharifi, A.; Mirzaei, M.; Naimi-Jamal, M. R. Solvent-free aminoalkylation of phenols and indoles assisted by microwave irradiation. *Monatsh. Chem.* 2001, *132* (7), 875–880; (c) Sharifi, A.; Farhangian, H.; Mohsenzadeh, F.; Naimi-Jamal, M. R. Microwave assisted Mannich reaction of terminal alkynes on alumina. *Monatsh. Chem.* 2002, *133* (2), 199–204; (d) Sharifi, A.;

2-Phenyl-1,3,2-aryldioxaborins

Mirzaei, M.; Naimi-Jamal, M. R. Copper-catalysed oxidative homo-coupling of terminal acetylenes on alumina assisted by microwave irradiation. *J. Chem. Res. Synop.* **2002**, 628–630; (e) Sharifi, A.; Mirzaei, M.; Naimi Jamal, M. R. Mild and solvent-free alkynylation of ketones on the KF/alumina. *Synth. Commun.* **2005**, *35*, 1039–1044; (f) Sharifi, A.; Mirzaei, M.; Naimi Jamal, M. R. Modified Glaser reaction of terminal alkynes on KF/alumina. *Monatshefte Chemie* **2006**, *137*, 213–217.