

NEW SYNTHETIC ROUTE TO 3-FURYLPHOSPHONATES

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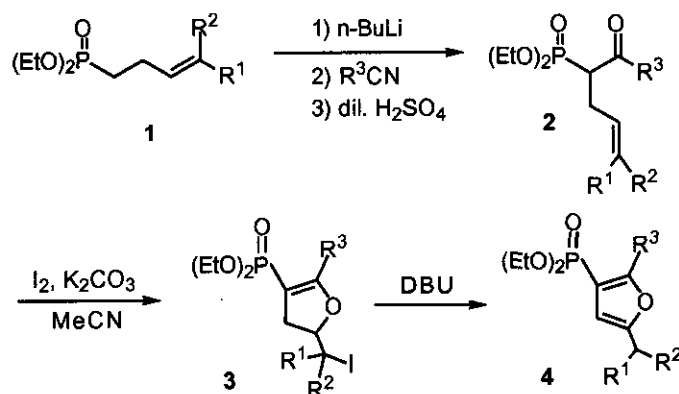
Abstract - A method for the preparation of 3-furylphosphonates has been developed starting with the addition of homoallylic phosphonates to nitrile, followed by a sequence consisting of acidic hydrolysis, iodine-mediated cyclization and dehydroiodination by DBU.

In contrast to the significant number of preparations of arylphosphonates,¹ only a few reports are found in the literature for the preparation of furylphosphonates.² A literature survey on the preparation of 2-furylphosphonates showed that some of the methods reported involve the photoinitiated arylation of trialkyl phosphites,^{2a} and the reaction of 2-furyllithium with diethyl chlorophosphate.^{2c} But there is only one literature about the method for the preparation of 3-furylphosphonate to our knowledge.³ Therein, 3-furylphosphonates were obtained through halophilic attack of a phosphite anion, but halophilic attack occurs only when the bromomethyl group in furan is conjugated with the ethoxycarbonyl group.

Recently, we have developed method for the synthesis of 2,4-disubstituted furans,⁴ and β -diethoxyphosphinyl- β,γ -unsaturated ketones *via* iodocyclization.⁵ As an extension of these methods we investigated a new route to 3-furylphosphonates *via* iodocyclization. The

method is depicted in **Scheme 1**.

Scheme 1



Treatment of lithiated homoallylic phosphonates (**1**) with nitriles followed by hydrolysis with 5N H_2SO_4 gave the 2-oxophosphonate derivatives (**2**).⁶ The reaction of 2-oxophosphonates (**2**) with 1.5 equiv. of K_2CO_3 and 2 equiv. of iodine in dry acetonitrile at room temperature afforded dihydrofurans (**3**). The conversion of **2** to **3** could be reasonably explained by assuming the formation of a iodonium ion, which allow an intramolecular attack by enolic $-\text{OH}$,⁷ leading to the cyclization product (**3**). And the dehydroiodination of dihydrofurans (**3**) by DBU in anhydrous THF and subsequent basic isomerization gave 3-furylphosphonates (**4**) in good overall yields from **1** (**Table 1**).

Table 1. Synthesis of 3-Furylphosphonates *via* Iodocyclization

3-Furylphosphonate	R^1	R^2	R^3	Yield (%)
4a	H	H	Ph	80
4b	H	H	<i>p</i> -Cl-Ph	83
4c	H	H	<i>p</i> -CH ₃ O-Ph	80
4d	Me	H	<i>p</i> -Cl-Ph	66
4e	Me	Me	<i>p</i> -Cl-Ph	63
4f	Ph	H	<i>p</i> -Cl-Ph	57

When the reaction was carried out with aliphatic nitriles, we have found none of the desired 2-

oxophosphonate derivatives (**2**). In the case of synthesis of **4f** ($R^1=Ph$, $R^2=H$), **2f** could be prepared as in the literature⁸ not by the above method, because the acylation step of homoallylic phosphonate (**1f**) afforded 2-oxophosphonate (**2f**) in low yield.

When *t*-BuOK was used in place of DBU, the desired product could not be obtained.

In summary, we have developed a new alternative and mild route to 3-furylphosphonates. Although this procedure involved the well-known halocyclization, the reaction pathway proved to be of a significant value since it is the first approach to the synthesis of 3-furylphosphonates *via* iodocyclization.

Representative Procedure.

To a solution of diethyl 3-butenylphosphonate (**1**) (1 mmol) in 5 ml of THF was added dropwise a solution of 1.6 M *n*-BuLi (0.69 ml, 1.1 mmol) in hexane at $-78\text{ }^{\circ}\text{C}$. After stirring for 1 h at this temperature, a solution of benzonitrile (1.1 mmol) in 5 ml of THF was added dropwise and the reaction mixture was stirred at room temperature for 30 min under N_2 , followed by addition of 5N H_2SO_4 (2 ml). After usual work-up, to the reaction mixture in dry acetonitrile (30 ml) was added iodine (558.4 g, 2.2 mmol) and K_2CO_3 (207.3 g, 1.5 mmol). The mixture was stirred for 2 h at room temperature. To the resultant solution was added saturated aq. sodium thiosulfate and the mixture was extracted with CH_2Cl_2 . Then the combined organic extracts were concentrated and treated with DBU (380.6 g, 2.5 mmol) in 5 ml of THF at room temperature. After 3 h, the mixture was quenched and extracted with CH_2Cl_2 . The combined organic extracts were dried with $MgSO_4$, and concentrated *in vacuo*. The mixture was purified by silica gel chromatography.

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REFERENCES

1. T. Hirao, T. Masunaga, Y. Ohshiro, and T. Agawa, *Synthesis*, 1981, 56; T. Hirao, T. Masunaga, N. Yamada, Y. Ohshiro, and T. Agawa, *Bull. Chem. Soc. Jpn.*, 1982, **55**, 909 ; A. Osuka, N. Ohmasa, Y. Yoshida, and H. Suzuki, *Synthesis*, 1983, 69 ; X. Lu and J. Zhu, *Synthesis*, 1987, 726.
2. R. Obrycki and C. E. Griffin, *J. Org. Chem.*, 1968, **33**, 632 ; S. Andreae and H. Seeboth, *Z. Chem.*, 1979, **19**, 98 (*Chem. Abstr.*, 1979, **91**, 20607k) ; S. Andreae and H. Seeboth, Ger. (East) Patent 136,501 1979 (*Chem. Abstr.*, 1979, **92**, 58975n).
3. L. M. Pevzner, V. M. Ignat'ev, and B. I. Ionin, *Zhur. Obshch. Khim.*, 1994, **64**, 1108.
4. J. H. Jung, J. W. Lee, and D. Y. Oh, *Tetrahedron Lett.*, 1995, **36**, 923.
5. C. -W. Lee, J. E. Hong, and D. Y. Oh, *J. Org. Chem.*, 1995, **60**, 7027.
6. K. Lee and D. Y. Oh, *Synthesis*, 1991, 213.
7. R. Anonioletti, F. Bonadies, and A. Scettri, *Tetrahedron Lett.*, 1988, **29**, 4987 ; J. Barluenga, M. Tomàs, and A. Suarez-Sobrino, *Synlett*, 1990, 673.
8. K. Lee and D. Y. Oh, *Bull. Korean Chem. Soc.*, 1989, **10**, 613.

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