ChemComm

Triphenylphosphine-mediated olefination of aldehydes with (*Z*)-(2-acetoxyalk-1-enyl)phenyl-λ³-iodanes: generation and reaction of (2-oxoalkyl)phenyl-λ³-iodanes

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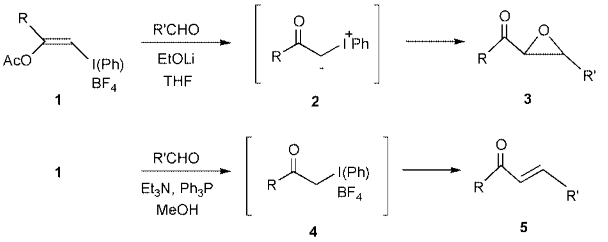
Received (in Cambridge, UK) 17th April 2000, Accepted 22nd May 2000

(*Z*)-(2-Acetoxyalk-1-enyl)phenyl-λ³-iodanes, on treatment with triethylamine in methanol in the presence of triphenylphosphine, undergo Wittig olefination with aldehydes, which involves the intermediacy of α-iodanyl ketones generated by *in situ* protonation of monocarbonyl iodonium ylides.

Recently, we reported that the ester exchange reaction of (*Z*)-(2-acetoxyalk-1-enyl)phenyl-λ³-iodanes **1** with EtOLi quantitatively generates the unstabilized monocarbonyl iodonium ylides **2** in THF at −78 °C with the liberation of ethyl acetate (Scheme 1).[1] In a marked contrast to the stable iodonium ylides derived from β-dicarbonyl compounds,[2] the monocarbonyl iodonium ylides **2** are moderately nucleophilic and undergo nucleophilic attack towards carbonyl compounds and activated imines. In general, ylides react with carbonyl compounds in either of two possible reaction modes, Wittig type reaction yielding alkenes and Corey type reaction leading to the formation of epoxides, depending on the nature of ylides and carbonyl compounds.[3] Because of the very high reductive nucleofugality of the λ³-phenyliodanyl groups,[4] monocarbonyl iodonium ylides **2** exclusively undergo alkylidene transfer reactions (Corey type) with aldehydes yielding epoxides:[1a] thus, the reaction of **1** with aldehydes in the presence of EtOLi gives α,β-epoxy ketones **3** in good yields with *trans*-isomers as the major product. No formation of the Wittig type olefination products **5** was observed in this reaction. The reaction course, however, was dramatically altered to the Wittig olefination pathway, when both the base and the solvent were changed to triethylamine and methanol, and the reaction was carried out in the presence of triphenylphosphine. We report herein triphenylphosphine-mediated Wittig olefination of aldehydes with (*Z*)-(2-acetoxyalk-1-enyl)phenyl-λ³-iodanes **1**, which involves an efficient generation of (2-oxoalkyl)phenyl-λ³-iodanes **4** under mild conditions.



1a R = Me, **1b** R = C_8H_{17}, **1c** R = $Ph(CH_2)_3$, **1d** R = Bu^t

Scheme 1

To a stirred solution of (*Z*)-2-acetoxydec-1-enyl(phenyl)-λ³-iodane **1b** and triphenylphosphine (2 equiv.) in MeOH was added triethylamine (1.3 equiv.) at room temperature under nitrogen and the mixture was stirred for 30 min. A solution of benzaldehyde (1.5 equiv.) in MeOH was added and the mixture was heated at 60 °C for 24 h. After usual workup, preparative TLC [hexane–ethyl acetate (10 : 1)] afforded a 98 : 2 mixture of (*E*)- and (*Z*)-1-phenylundec-1-en-3-one **5c** in 73% yield. No evidence for formation of the epoxide **3** (R = C_8H_{17}, R′ = Ph) was observed in this reaction. The results of the Wittig type reaction of aldehydes with the vinyl(phenyl)-λ³-iodanes **1** are summarized in Table 1. The vinyl-λ³-iodanes **1a–c** readily undergo Wittig olefinations with aromatic aldehydes containing electron-withdrawing or -donating substituents as well as with aliphatic aldehydes to give α,β-unsaturated ketones **5** with high *trans* selectivity. With α,β-unsaturated aldehydes, selective reaction at the carbonyl group was observed with no evidence for Michael addition yielding cyclopropanes (entries 9 and 16). With the use of the sterically demanding λ³-iodane, β-*tert*-butylvinyliodane **1d**, the Wittig olefination becomes sluggish (entry 17).

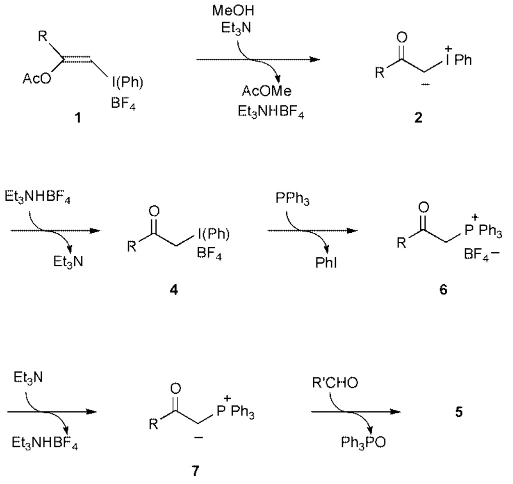
Table 1 Wittig olefinations of aldehydes with *β*-acetoxyvinyl(phenyl)-λ³-iodanes **1**[a]

				Product (yield (%))[b]	
Entry	1	R′CHO (R′)	*t*/h	5	Ratio[c]
1	**1a**	Ph	24[d]	**5a** (62)	93 : 7
2	**1a**	*n*-C_9H_{19}	48[d]	**5b** (60)	100 : 0
3	**1b**	Ph	24	**5c** (73)	98 : 2
4	**1b**	*p*-$MeOC_6H_4$	24	**5d** (45)	99 : 1
5	**1b**	*p*-MeC_6H_4	24	**5e** (64)	99 : 1
6	**1b**	*p*-ClC_6H_4	24[d]	**5f** (85)	91 : 9
7	**1b**	*p*-$NO_2C_6H_4$	40[d]	**5g** (86)	93 : 7
8	**1b**	*n*-C_9H_{19}	48	**5h** (65)	100 : 0
9	**1b**	*E*-MeCH=CH	42[d]	**5i** (57)	100 : 0
10	**1c**	Ph	24	**5j** (58)	92 : 8
11	**1c**	*p*-MeC_6H_4	24	**5k** (62)	100 : 0
12	**1c**	*p*-$MeOC_6H_4$	24	**5l** (75)	95 : 5
13	**1c**	*p*-ClC_6H_4	24	**5m** (60)	99 : 1
14	**1c**	*p*-$NO_2C_6H_4$	24	**5n** (82)	> 99 : 1
15	**1c**	*n*-C_9H_{19}	24	**5o** (53)	100 : 0
16	**1c**	*E*-MeCH=CH	24	**5p** (48)	100 : 0
17	**1d**	*p*-ClC_6H_4	24	**5q** (10)	99 : 1

[a] Reactions were carried out at 60 °C under N_2. [b] Isolated yields. [c] *Trans* : *cis* ratio. [d] Reactions were carried out at 25 °C under N_2.

As illustrated in Scheme 2, a mechanism for the Wittig olefination of aldehydes upon reaction with (*Z*)-(2-acetoxyalk-1-enyl)-λ³-iodanes **1** in the presence of triethylamine and triphenylphosphine in MeOH might be assumed to involve the following key steps: (i) ester exchange of β-acetoxyvinyl-λ³-iodanes **1** with MeOH under basic conditions generating the monocarbonyl iodonium ylides **2** with the liberation of methyl acetate, (ii) formation of (2-oxoalkyl)-λ³-iodanes **4** *via* protonation of the ylides **2** with the resulting Et_3NHBF_4, (iii) bimolecular nucleophilic substitution of **4** with triphenylphosphine yielding (2-oxoalkyl)phosphonium salts **6**, and (iv) Wittig olefination of aldehydes with β-acylphosphonium ylides **7** produced from **6** by reaction with regenerated triethylamine. This mechanism involves the *in situ* generation and conversion of the monocarbonyl iodonium ylides **2** which undergo Corey type reaction to the monocarbonyl phosphonium ylides **7** which

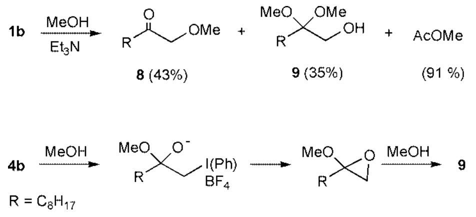
DOI: 10.1039/b003090m



Scheme 2

undergo Wittig olefination. Alternatively, the (2-oxoalkyl)iodanes **4** might be directly produced *via* triethylamine-mediated ester exchange of vinyliodanes **1** with MeOH.

Several experimental observations are in line with this proposed mechanism. Reaction of **1b** with triethylamine (1.1 equiv.) in MeOH (25 °C, 1 h) afforded a mixture of α-methoxy ketone **8** (43%), hydroxy dimethylacetal **9** (35%) and methyl acetate (91%) (Scheme 3). Without triethylamine, **1b** was recovered unchanged in MeOH. High yield formation of methyl acetate clearly indicates the intervention of the ester exchange between β-acetoxyvinyliodane **1b** and MeOH under basic conditions. Bimolecular nucleophilic substitution of (2-oxoalkyl)iodane **4b** with MeOH will produce the α-methoxy ketone **8**. Furthermore, formation of the hydroxy dimethylacetal **9** under basic conditions strongly suggests the intermediacy of the (2-oxoalkyl)iodane **4b** in this reaction (Scheme 3), as reported by Moriarty *et al.*[5] It has been reported that the presence of the λ^3-phenyliodanyl group raises the CH acidity of malonic esters by eight orders of magnitude.[6] Based on these data, the acidity (pK_a) of α-methylene protons of (2-oxoalkyl)iodanes **4** is estimated to be *ca.* 12. Therefore, it seems reasonable to assume that Et_3NHBF_4 with similar acidity (pK_a = 11.0),[7] undergoes proton transfer to the monocarbonyl iodonium ylides **2** yielding the (2-oxoalkyl)iodanes **4**.



Scheme 3

It is possible to isolate the intermediate (2-oxoalkyl)phosphonium salts **6**: treatment of **1b** with triethylamine and triphenylphosphine in MeOH at room temperature, after acidification of the reaction mixture with 5% aqueous HBF_4 solution, afforded the phosphonium tetrafluoroborate **6b** in 89% yield. Without acid treatment, the monocarbonyl phosphonium ylide **7b** was obtained, thereby illustrating the occurrence of transylidation between iodonium and phosphonoim ylides under such conditions. The formation of phosphonium ylides **7** is compatible with the reported acidity of acetonyl(triphenyl)phosphonium salt **6a** (R = Me, pK_a = 6.6), *i.e.* more acidic than Et_3NHBF_4.[8]

In conclusion, we have developed an efficient one-pot procedure for Wittig olefination of aldehydes with (*Z*)-(2-acetoxyalk-1-enyl)phenyl-λ^3-iodanes **1**. In addition to the reported Corey type alkylidene-transfer reaction of the monocarbonyl iodonium ylides to aldehydes, this new strategy developed here makes vinyl-λ^3-iodanes **1** valuable progenitors in monocarbonyl onium ylide chemistry.

Notes and references

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