

Tetrahedron Letters 42 (2001) 3105-3107

## Convenient synthesis of aryl-substituted halo olefins from aromatic ketones and acetyl halides in the presence of silica gel-supported zinc halides

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Abstract—A simple and efficient procedure has been developed for the synthesis of aryl-substituted chloro and bromo olefins from aromatic ketones and acetyl halides in the presence of silica gel-supported zinc halides. The Z-isomer is selectively formed. © 2001 Elsevier Science Ltd. All rights reserved.

Aryl-substituted chloro and bromo olefins are important intermediates in organic synthesis. Many methods have been developed for the synthesis of substituted halo olefins, but most of these methods are not fully satisfactory with regard to yield, reaction conditions, generality and operational simplicity. One of the most preferred routes to prepare substituted olefins is by reacting a phosphonate carbanion with a carbonyl compound via the Horner-Wadsworth-Emmons reaction.<sup>1</sup> Synthesis of aryl-substituted halo olefins by this route would require the corresponding halogenophosphonates.<sup>2</sup> The carbanion generated from diethyl achlorophenylmethanephosphonate reacts with aldehvdes or ketones to give 1-chloro-1-phenvl-1-alkenes.<sup>3</sup> However, this method requires a strong base, and the stereoselectivity is low. Recently, the preparation of vinyl halides by using arsonium ylides,<sup>4</sup> and by treating ketones with acetyl halides in a strongly acidic solvent, such as trifluoroacetic acid,<sup>5</sup> has been reported. In the course of our studies aimed at developing supported reagents as catalysts for the Friedel-Crafts reaction,<sup>6</sup> we found that the reaction of anisole with phenylacetyl chloride using ZnCl<sub>2</sub>/SiO<sub>2</sub> as a catalyst affords chlorostilbene 2 as well as the expected acylated product 1 (Scheme 1).

Similar products have been seen in the Montmorillonite-supported  $\text{FeCl}_3$ -catalyzed Friedel–Crafts acylation.<sup>7</sup> When the ratio of acetyl halides to anisole increased, acylated product 1 decreased and chlorostilbene 2 became a significant product. It was found that 2 is formed by reacting excess acetyl chloride with 1. We wish to report here a simple and practical procedure for the synthesis of aryl-substituted halo olefins from readily available aromatic ketones and acetyl halides.

In a typical procedure, a mixture of benzyl phenyl ketone (0.196 g, 1 mmol), acetyl chloride (0.628 g, 8 mmol) and  $ZnCl_2/SiO_2^{\ 8}$  (0.68 g) in dichloroethane (10 ml) was stirred at 30°C for 4 h.  $ZnCl_2/SiO_2$  was removed by filtration and the filtrate was washed with aq. NaHCO<sub>3</sub> to remove excess acetyl chloride. The filtrate was then dried and evaporated to leave crude products, which were purified by column chromatography over silica gel. (*Z*)-1-Chloro-1,2-diphenylethene<sup>9</sup>



Scheme 1.

Keywords: halo olefin; ketone; acetyl halide; silica gel-supported zinc chloride.

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Table	1.	Preparation	of	aryl-su	bstituted	halo	olefins <sup>a</sup>
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Entry	Ketone Ar	Ketone ( <b>3</b> ) Ar R		Time (h)	Yield of 5 <sup>b</sup> (%)
1	Ph	CH3-	Cl	1	91
2	Ph	CH <sub>3</sub> CH <sub>2</sub> -	Cl	1	97
3	Ph	CH <sub>3</sub> CH <sub>2</sub> -	Br	0.5	67
4	Ph	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>5</sub> -	Cl	1	99
5	Ph	Ph	Cl	4	90
6	Ph	Ph	Br	4	88
7	<i>p</i> -Me-Ph	CH <sub>3</sub> CH <sub>2</sub> -	Cl	1	85
8	<i>p</i> -Me-Ph	Ph	Cl	4	85
9	<i>p</i> -Me-Ph	Ph	Br	4	78
10	p-MeO-Ph	CH <sub>3</sub> CH <sub>2</sub> -	Cl	0.5	76
11	p-MeO-Ph	Ph	Cl	4	75
12	p-MeO-Ph	Ph	Br	4	54
13	p-Cl-Ph	CH <sub>3</sub> CH <sub>2</sub> -	Cl	1	93
14	p-Cl-Ph	CH <sub>3</sub> CH <sub>2</sub> -	Br	1	80
15	p-Cl-Ph	Ph	Cl	24	82
16	p-Cl-Ph	Ph	Br	4	85
17		CH <sub>3</sub> CH <sub>2</sub> -	Cl	7	92
18	H <sub>3</sub> C-(S)-	CH <sub>3</sub> CH <sub>2</sub> -	Cl	0.5	91

a. The reaction was carried out at 30°C in 1,2-dichloroethane. [ketone]:[halide]:[ $ZnX_2/SiO_2$ ] = 1:8:1 (in mmol).

b. By GLC, all products were characterized by  $^1\mathrm{H},\,^{13}\mathrm{C}$  NMR, IR spectroscopy and mass spectrometry.

was obtained in 90% yield (0.194 g) as a white solid. The reaction using zinc chloride alone under similar conditions afforded only 37% yield of the chlorostilbene product. The reaction could be carried out by using FeCl<sub>3</sub> and SnCl<sub>4</sub> instead of ZnCl<sub>2</sub>/SiO<sub>2</sub>, but AlCl<sub>3</sub> was ineffective.  $ZnCl_2/SiO_2$  is the most effective among these Lewis acids and can be removed from the reaction mixture by filtration. When phenylacetyl chloride or benzoyl chloride was used instead of acetyl chloride, the same product as for the reaction with acetyl chloride was obtained, but these yields were lower than that in the reaction with acetyl chloride. The yield of the chlorostilbene product increased with increasing the amount of acetyl chloride against the ketone. As shown in Table 1, aryl benzyl ketones and aryl alkyl ketones react with acetyl halides to produce the corresponding halostilbene and halostyrene products in high yields, respectively, but aliphatic ketones did not react.

Silica gel-supported zinc bromide was used for the preparation of the bromo olefins since the ketones reacted with acetyl bromide in the presence of  $ZnCl_2/SiO_2$  to give chloro olefins as well as bromo olefins. Bromo olefins were less stable than chloro olefins

(entries 3, 9, and 12). The yield of 1-bromo-1-(4methoxyphenyl)-2-phenylethene in the reaction of 4methoxyphenyl benzyl ketone with acetyl bromide decreased when the reaction time was prolonged. All aryl-substituted halo olefins prepared from the ketones show only the *E*-isomer in <sup>1</sup>H and <sup>13</sup>C NMR spectra,<sup>10</sup> except in the case of entry 6 in which a mixture of Zand *E*-isomers was formed in approximately a 5:1 ratio. In the synthesis of aryl-substituted chloro and bromo olefins from halogenophosphonates and ketones, a mixture of the E- and Z-isomers is formed, and aryl-substituted bromo olefins are difficult to obtain.11 Aryl alkyl ketones reacted with acetyl halides to give halostyrene products in high yields. When the reaction time was prolonged, the yields of halostyrene products decreased owing to decomposition of the products. This is in agreement with the observation made by Bastock et al.<sup>7</sup>







## Scheme 4.

Scheme 3.

(Scheme 2). Ethyl phenyl ketone afforded the corresponding chlorostyrene in 91% yield, whereas acetophenone did not react with acetyl chloride and unchanged acetophenone was recovered. Naphtyl ketones and acylthiophenes also react with acetyl halides to give the corresponding halo olefins in high yields. For example, reaction of 2-methyl-4-butyrylthiophene with acetyl chloride in the presence of  $ZnCl_2/SiO_2$  was carried out in 1,2-dichloroethane at 30°C for 0.5 h to afford the corresponding vinyl chloride in 91% yield (entry 18). The bromostilbene products were easily transformed into the corresponding alkynes through elimination reaction with potassium hydroxide/methanol (Scheme 3).

This route to aryl-substituted halo olefins from ketones and acetyl halide is different from the mechanism proposed by Bastock et al.<sup>7</sup> for the formation of chlorostyrene products in the reaction of anisole with acyl chloride. Either acetyl chloride or phenylacetyl chloride in the reaction with a ketone afforded the same chlorostyrene product. From these results, the formation of halo olefins in the reaction of ketones with acetyl halides probably proceeds through addition of acetyl halides to the carbonyl, resulting in an  $\alpha$ -haloacetate, followed by elimination of acetic acid.<sup>5</sup>

Acetyl halides add to the carbonyl of aldehydes to give  $\alpha$ -haloacetate in the presence of zinc chloride<sup>12</sup> (Scheme 4).

In conclusion, the present procedure using silica gelsupported  $ZnCl_2$  provides an efficient synthesis of arylsubstituted halo olefins from readily available aromatic ketones and acetyl halides. The notable advantages of this procedure are: (a) operational simplicity; (b) mild conditions; (c) high yield; (d) stereoselectivity; and (e) no phosphorous-containing reagents are used. We believe this will provide a better and more practical alternative to the existing methodologies for the synthesis of aryl-substituted halo olefins.

## References

- 1. Boutagy, J.; Thomas, R. Chem. Rev. 1974, 74, 87.
- Kumaraswamy, S.; Kumara Swamy, K. C. Tetrahedron Lett. 1997, 38, 2183.
- Petrova, J.; Coutrot, P.; Dreux, M.; Savignac, P. Synthesis 1975, 658.
- Huang, Z. Z.; Lan, G. C.; Haung, X. Synth. Commun. 1998, 28, 633.
- Moughamir, K.; Mezgueldi, B.; Atmani, A.; Mestdagh, H.; Rolando, C. *Tetrahedron Lett.* 1999, 40, 59.
- 6. Kodomari, M.; Taguchi, S. J. Chem. Res. (S) 1996, 240.
- Bastock, T. W.; Clark, J. H.; Landon, P.; Martin, K. J. Chem. Res. (S) 1994, 104.
- 8. Silica gel-supported zinc chloride was prepared as follows. Silica gel (Wakogel C-200, 40 g) was added to a solution of zinc chloride (10 g) in water (100 ml) and the mixture was stirred at room temperature for 0.5 h. The water was removed by rotary evaporation and the resulting reagent was then dried in vacuo (15 mmHg) at 150°C for 12 h.
- Cristol, S. J.; Whittemore, C. A. J. Org. Chem. 1969, 34, 705.
- 10. Fahey, R. F.; Schubert, C. J. Am. Chem. Soc. 1965, 87, 5172.
- Yamaguchi, A.; Okazaki, M. Nippon Kagaku Kaishi 1972, 2103.
- Bigler, P.; Muhler, H.; Neuenschwander, M. Synthesis 1978, 593.