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Conversion of aromatic aldehydes to *gem*-dichlorides using boron trichloride. A new highly efficient method for preparing dichloroarylmethanes

George W. Kabalka* and Zhongzhi Wu

Departments of Chemistry and Radiology, The University of Tennessee, Knoxville, TN 37996-1600, USA

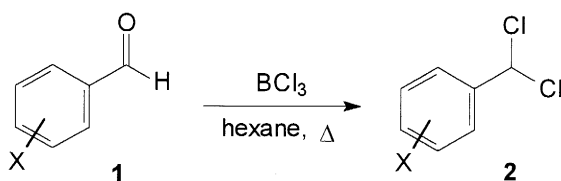
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Abstract

The chlorination of aromatic aldehydes with boron trichloride in hexane under reflux conditions produces the corresponding dichloromethyl derivatives in excellent yields. © 2000 Elsevier Science Ltd. All rights reserved.

The chlorination of aldehydes to the corresponding *gem*-dichlorides is a very useful transformation in organic synthesis since the product dichloroarylmethanes are of value in the pharmaceutical and agricultural industries.¹ Generally, PCl_5 is used to generate geminal dichlorides.² Other methods include the use of $\text{PhCCl}_3/\text{FeCl}_3$,³ $\text{SeO}_2/\text{Me}_3\text{SiCl}$,⁴ SOCl_2/DMF ⁵ and $\text{SOCl}_2/(\text{Me}_2\text{N})_3\text{PO}$ ⁶ as chlorination reagents. Recently, the oxophilic *d*-block metal chlorides were used to chlorinate aromatic aldehydes.⁷ However, all these methods require either high temperature or toxic reagents.

Boron trichloride has been extensively used as a reagent for the cleavage of a wide variety of ethers.⁸ To our knowledge, it has not been utilized to convert aldehydes to the corresponding geminal dichlorides. During a recent study of an aldol–Grob reaction sequence catalyzed by boron trihalides, we found that BCl_3 failed as a catalyst.⁹ On closer examination, we discovered that BCl_3 reacts with aromatic aldehydes to generate the corresponding geminal dichlorides in excellent yields (Scheme 1). The reaction provides an efficient method for generating these useful products.



Scheme 1.

A series of aromatic aldehydes were subjected to the new reaction (Table 1). Essentially all of the

* Corresponding author.

Table 1
Chlorination of aromatic aldehydes with boron trichloride in hexane^a

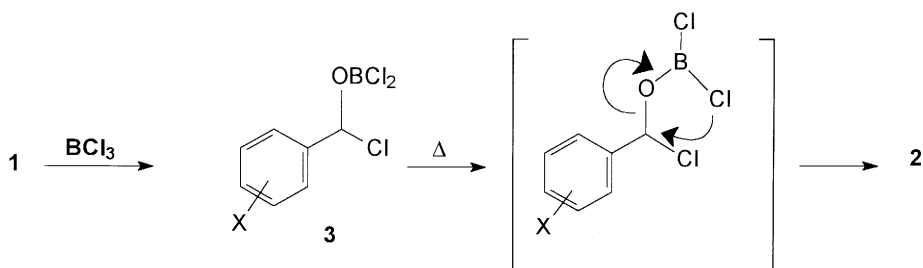
Entry	Substrate	Product ^b	Time (hr)	Yield% ^c
1	C ₆ H ₅ CHO	C ₆ H ₅ CHCl ₂	2	90
2	<i>p</i> -ClC ₆ H ₄ CHO	<i>p</i> -C ₆ H ₄ CHCl ₂	2	94
3	<i>o</i> -ClC ₆ H ₄ CHO	<i>o</i> -ClC ₆ H ₄ CHCl ₂	2	96
4	<i>p</i> -BrC ₆ H ₄ CHO	<i>p</i> -BrC ₆ H ₄ CHCl ₂	2	99
5	<i>m</i> -BrC ₆ H ₄ CHO	<i>m</i> -BrC ₆ H ₄ CHCl ₂	2	99
6	<i>p</i> -NO ₂ C ₆ H ₄ CHO	<i>p</i> -NO ₂ C ₆ H ₄ CHCl ₂	12	76
7	<i>m</i> -NO ₂ C ₆ H ₄ CHO	<i>m</i> -NO ₂ C ₆ H ₄ CHCl ₂	12	82
8	<i>p</i> -MeC ₆ H ₄ CHO	<i>p</i> -MeC ₆ H ₄ CHCl ₂	1	94
9	1,4-(CHO) ₂ C ₆ H ₄	1,4-(CHCl ₂) ₂ C ₆ H ₄	4	98

^aAll reactions were carried out in hexane under reflux conditions. ^bAll reaction products exhibited physical and spectral characteristics in accord with literature values. ^cIsolated yield based on aldehyde.

aromatic aldehydes investigated were successfully converted to the corresponding dichlorides with the exception of *p*-anisaldehyde;^{8,10} the BCl₃ cleavage of the methoxy ether moiety competes effectively with the formation of the desired dichloride as evidenced by the presence of phenolic byproducts. As can be seen from the data presented in Table 1, aldehydes with strong electron withdrawing groups such as the nitro group proceed at a slower rate.

Although a detailed mechanistic study has not been undertaken, we found that benzaldehyde reacts with BCl₃ in hexane at room temperature to form a white solid. We were able to isolate this solid by removing hexane solvent from the reaction mixture at -10°C (benzaldehyde was formed upon addition of water to this solid). The NMR spectra of the solid (in C₆D₆) were recorded and revealed that the characteristic ¹H and ¹³C resonances for the aldehyde group were absent but that new ¹H and ¹³C NMR resonances were present at 7.02 and 92.5 ppm, respectively. The spectral data are consistent with the formation of an intermediate, **3**, in which one chlorine has migrated to the carbonyl carbon to form an alkoxyboron dichloride. This intermediate presumably then undergoes migration of the second chlorine to give **2**, as shown in Scheme 2.

The synthesis of dichlorophenylmethane is representative. Benzaldehyde (2.0 mmol, 0.21 g) is dissolved in hexane (10 mL) at room temperature in a dry flask maintained under a nitrogen atmosphere. Boron



Scheme 2.

trichloride (2.0 mmol, 2.0 mL of a 1.0 M solution in hexane) is added to the aldehyde solution at room temperature with the immediate formation of a white precipitate. The reaction mixture is then refluxed for the indicated time. Water (5 mL) is added to the reaction mixture, the organic layer is separated and the product isolated by column chromatography (hexanes, silica gel) to yield 0.29 g (90%) of the desired product.

The reaction of BCl_3 with aromatic aldehydes provides a general, high yield method for preparing dichloroarylmethanes. The method is not suitable for the preparation of geminal dichlorides from carbonyl compounds containing enolizable hydrogens.

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