

Silicon Assisted Halogenation III: Tetrachlorosilane Induced Benzylic Bromination with N-Bromosuccinimide at Room Temperature[†]

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ABSTRACT- A new convenient procedure for the bromination of aromatic side chains was efficiently achieved by using a combination of tetrachlorosilane (TCS) and N-bromosuccinimide (NBS) at ambient conditions.

KEYWORDS: Tetrachlorosilane; N-Bromosuccinimide; Benzylic bromination;

INTRODUCTION

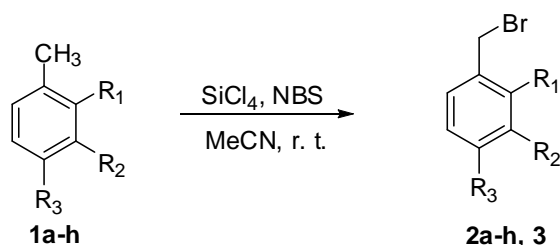
Halogenation of side chain aromatics represents a very useful route to benzyl halides which are widely used in fields of synthetic organic chemistry and material science.¹ However, N-haloimides are widely used for benzylic halogenation, harsh conditions are usually required.² For example, Wohl-Ziegler bromination, which is one of the most popular methods of obtaining α -brominated alkyl arenes, is usually performed with N-bromosuccinimide (NBS) in the presence of a radical initiator at high temperature in solvent CCl₄.³ A major drawback of carbon tetrachloride, however, is its toxicity and carcinogenicity and also its properties of ozone-layer damaging.⁴ Consequently, research has focused on using NBS and non-chlorinated solvent,⁵ ionic liquids,⁶ and water.^{2c,7} In addition, little attention has been given to investigating the Wohl-Ziegler reaction at lower temperature. In two recent reports, Shibatomi *et al.* performed side-chain bromination of aromatic compounds with ZrCl₄/NBS,^{2b} or ZrCl₄/1,3-dibromo-5,5-dimethylhydantoin (DBDMH) at ambient conditions.⁸ Some other metal halides such as TiCl₄, AlCl₃, Tf₂NAICl₂, Cy₂BCl also catalyzed benzylic bromination with DBDMH.⁸ Recently, benzylic brominations have been developed by using either N,N,N',N'-tetrabromobenzene-1,3-disulfonamide (TBBDA), poly(N,N'-dibromo-N-ethylbenzene-1,3-disulfonamide (PBBS), or poly(N,N'-dibromo-N-phenylbenzene-1,3-disulfonamide (PBPS).⁹ Hydrogen peroxide - hydrogen bromide / water,^{7,10} bromine / water

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under irradiation,¹¹ and NaBrO₃-NaHSO₃/EtOAc-H₂O¹² were also employed for achieving such transformation. In conjunction with our interest in exploring the utility of *in situ* reagents based on tetrachlorosilane (TCS)¹³ in organic synthesis, the present communication describes a facile and mild procedure for the bromination of aromatic side chains to give selectively the corresponding α -brominated alkyl arenes in good yields utilizing the inexpensive and readily available tetrachlorosilane-*N*-bromosuccinimide system without using CCl₄ at ambient temperature.

RESULTS AND DISCUSSION

The reaction of substituted toluenes with SiCl₄-NBS works well giving good yields of respective benzyl bromides after aqueous work up. The generality and versatility of this procedure was examined, a number of alkyl benzenes underwent the benzylic bromination efficiently (Scheme 1, Table1).



1a, 2a: R₁ = R₂ = R₃ = H
1b, 2b: R₁ = Cl, R₂ = R₃ = H
1c, 2c: R₁ = R₂ = H, R₃ = Cl
1d, 2d: R₁ = R₃ = H, R₂ = Br
1e, 2e: R₁ = R₂ = H, R₃ = Br
1f, 2f: R₁ = Cl, R₂ = Me, R₃ = H
1g, 2g: R₁ = Me, R₂ = R₃ = H
3: R₂ = R₃ = H, R₁ = CH₂Br

Scheme 1

Table 1. Bromination of aromatic side chains with TCS-NBS reagent

Entry	Substrate	Time (h)	Product	Yield (%) ^a
1	Toluene	6	2a	82
2	2'-Chlorotoluene	7	2b	74
3	4'-Chlorotoluene	7	2c	69
4	3'-Bromotoluene	8	2d	75
5	4'-Bromotoluene	8	2e	84
6	2'-Chloro-1,3-dimethylbenzene	10	2f	72
7	<i>o</i> -Xylene	11	2g + 3	67, 28

^a Isolated yield

The structure of isolated benzyl bromide derivatives was assigned based on their spectral analyses as well as by matching their physical properties with reported analogues. It is noteworthy to mention that no reaction was observed in the absence of SiCl₄. Although the exact radical chain is not quite clear, the reaction seems to proceed via a radical mechanism at ambient light in a way similar to the ZrCl₄-catalyzed benzylic bromination.⁸ The radical pathway in the course of Lewis acid catalyzed reactions seems reasonable.^{8,14}

CONCLUSION

In conclusion, we have presented herein a new mild and efficient route to the synthesis of benzyl bromides via the Wohl-Ziegler reaction without using carbon tetrachloride as solvent at ambient conditions by using the cheap and readily available tetrachlorosilane with *N*-bromosuccinimide. Applying the present procedure to other *N*-haloimides for a general benzylic halogenation is currently in progress which may offer our method additional applications exploring the versatile role of tetrachlorosilane in organic synthesis.

EXPERIMENTAL

General procedure for the benzylic bromination:

To a mixture of methyl benzene derivative (5 mmol) and NBS (7 mmol) in CH₃CN (20 ml), SiCl₄ (7 mmol) was added and the reaction mixture was stirred at room temperature. On completion (the reaction was monitored by TLC), the mixture was quenched with cold water, extracted with CH₂Cl₂, dried over anhydrous MgSO₄ and the solvent was vaporized under vacuum and the residue was chromatographed using the eluent system hexane-ethyl acetate (30:1) to give pure **2c-g**, **3**. Data for **2e** as a representative example are showed below:

4-Bromobenzyl bromide 2e. Yield 84%; Purification by column chromatography using hexane-ethyl acetate (30:1) as eluent system; Colorless solid, m.p. 61-62°C (Lit.¹⁵ 62-64°C); ¹H-NMR (200 MHz, CDCl₃) δ 7.84 (d, *J* = 7.8 Hz, 2H), 7.42 (d, *J* = 7.8 Hz, 2H), 4.71 (s, 2H); EI-M.S.(*m/z*, %): 256 (M⁺-HCl, 81), 241 (33), 221 (35), 178 (31), 165 (32), 119 (84), 91 (100).

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