Halogenation Using Quaternary Ammonium Polyhalides. XXXII.[1] Dichlorination of Aromatic Acetyl Derivatives with Benzyltrimethylammonium Tetrachloroiodate

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(Received March 2, 1992)

Synopsis. The reaction of aromatic acetyl derivatives with 2 molar amounts of benzyltrimethylammonium tetrachloroiodate in acetic acid at 70 °C for several hours gave dichloroacetyl derivatives in good yields.

We have previously reported on the halogenation of aromatic acetyl derivatives (**1**) by the use of several ammonium polyhalides. That is, reaction of **1** with an equimolar amount of tetrabutylammonium tribromide (TBA Br_3)[2] or benzyltrimethylammonium tribromide (BTMA Br_3)[3] gave bromoacetyl derivatives, and reaction with 2 molar amounts of BTMA Br_3 gave dibromoacetyl derivatives.[3] Further, the reaction of **1** with 2 molar amounts of benzyltrimethylammonium dichloroiodate (BTMA ICl_2)[4] gave chloroacetyl derivatives. These products were obtained in good yields in all cases.

Incidentally, aromatic dichloroacetyl derivatives (**2**) have been prepared from arylacetylenes with ethyl hypochlorite in carbon tetrachloride[5] and with chlorine gas in alcohol.[6] As a synthesis of **2** from **1**, 2,2-dichlorophenylethanone (**2a**) has been prepared by the reaction of acetophenone (**1a**) with chlorine.[7] Chlorination of 3,3-dimethyl-2-butanone (**1p**) with chlorine gave 1-chloro-3,3-dimethyl-2-butanone as the main product and a small amount of 1,1-dichloro-3,3-dimethyl-2-butanone (**2p**).[8] However, chlorine is not always easy to use as a chlorinating agent in the laboratory because of its toxic gaseous character.

We have recently found that stable solid benzyltrimethylammonium tetrachloroiodate (BTMA ICl_4) is an effective chlorinating agent.[9-16] In this paper we wish to report the synthesis of **2** from **1** by the use of BTMA ICl_4.

Results and Discussion

The reaction of **1** with 2 molar amounts of BTMA ICl_4 in acetic acid at 70 °C for several hours gave **2** in good yields. The results are summarized in Table 1.

$$\underset{\mathbf{1}}{\text{Ar–COCH}_3} \xrightarrow[\text{AcOH, 70 °C}]{\text{2 BTMA ICl}_4} \underset{\mathbf{2}}{\text{Ar–COCHCl}_2}$$

In these reactions, the main active chlorinating species is probably acetyl hypochlorite that may be produced from a reaction of BTMA ICl_4 with acetic acid. The reaction scheme leading to **2** can be presented as follows:

$$2PhCH_2(CH_3)_3N^+ICl_4^- + 2CH_3COOH \longrightarrow 2PhCH_2(CH_3)_3N^+ICl_2^- + 2CH_3COOCl + 2HCl \quad (1)$$

$$\mathbf{1} + 2CH_3COOCl \longrightarrow \mathbf{2} + 2CH_3COOH \quad (2)$$

overall:

$$\mathbf{1} + 2PhCH_2(CH_3)_3N^+ICl_4^- \longrightarrow \mathbf{2} + 2PhCH_2(CH_3)_3N^+ICl_2^- + 2HCl \quad (3)$$

The by-product, BTMA ICl_2, produced is so insoluble in acetic acid at room temperature that it is easily separable from the reaction mixture.

We have already reported that the reaction of **1** with equimolar BTMA ICl_4 in refluxing 1,2-dichloroethane–methanol gave chloroacetyl derivatives (**3**) in good yields, and the main active species in these reactions was methyl hypochlorite (CH_3OCl).[23] However, we noticed that the reaction of **1** with 2 molar amounts of BTMA ICl_4 in 1,2-dichloroethane–methanol under reflux afforded **3** as main products and only a small amount of **2**, even though the reaction was carried out for many hours. Thus, it should be realized that the chlorinating reactivity of acetyl hypochlorite is stronger than that of methyl hypochlorite.

We believe that the procedure for the dichlorination of aromatic acetyl derivatives including 3,3-dimethyl-2-butanone by the use of BTMA ICl_4, a stable solid chlorinating agent, is efficient owing to its ease, simplicity, generality and good product yields. Furthermore, the by-product, BTMA ICl_2, is easily converted to BTMA ICl_4 by treatment with chlorine in dichloromethane.[9]

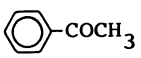
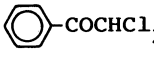
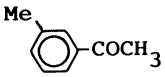
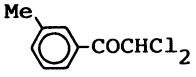
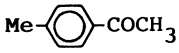
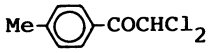
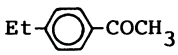
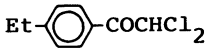
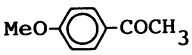
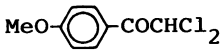
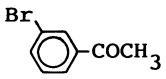
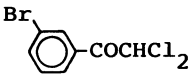
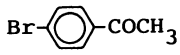
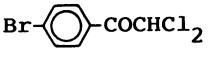
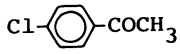
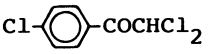
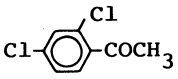
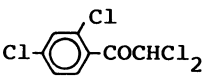
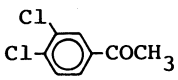
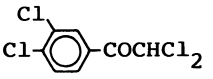
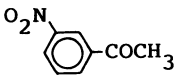
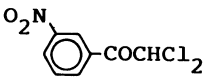
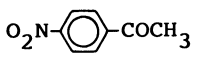
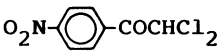
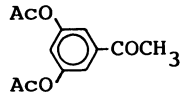
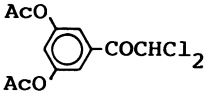
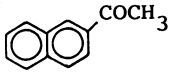
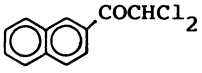
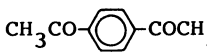
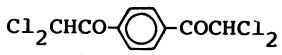
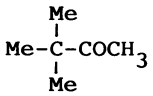
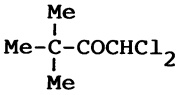
Experimental

2,2-Dichloro-1-phenyl-1-ethanone (2a); Typical Procedure: BTMA ICl_4 (4.18 g, 10 mmol) was added to a solution of acetophenone (**1a**) (0.60 g, 5 mmol) in acetic acid (50 ml), and the mixture was heated at 70 °C with stirring for 5 h. After the reaction mixture was cooled to room temperature, the precipitate, which was BTMA ICl_2, was filtered off. The filtrate was concentrated in vacuo and the residue was treated with 5% $NaHSO_3$ (10 ml) and with 5% $NaHCO_3$ (80 ml), and then extracted with ether (40 ml×4). The ether layer was dried ($MgSO_4$), filtered and evaporated in vacuo to give the product **2a** (Table 1).

2,2-Dichloro-1-*m*-tolyl-1-ethanone (2b): Colorless oil; ^1H NMR ($CDCl_3$) δ=2.37 (3H, s, CH_3), 6.70 (1H, s, $CHCl_2$), and 6.92—8.28 (4H, m, H_{arom}). Found: C, 53.12; H, 3.82%. Calcd for $C_9H_8OCl_2$: C, 53.23; H, 3.97%.

2,2-Dichloro-1-*p*-ethylphenyl-1-ethanone (2d): Colorless oil; ^1H NMR ($CDCl_3$) δ=1.25 (3H, t, J=8 Hz, $CH_2C\underline{H}_3$), 2.73

Table 1. α,α-Dichlorination of Aromatic Acetyl Derivatives with BTMA ICl_4 in AcOH

	Substrate (1)	Reaction time h	Product[a] (2)	Yield[b] %	IR (KBr or neat) $\nu_{C=O}/cm^{-1}$	Mp (°C) or Bp (°C)/Torr[d] Found[c]	Reported
a		5		90	1675 (neat)	243/760	245/760[7]
b		5		87	1685 (neat)	205/760	—
c		5		91	1685 (KBr)	53.5—54	55.5—56.5[17]
d		6		90	1700 (neat)	175/760	—
e		3		78	1680 (KBr)	77—78	75—76[18]
f		6		87	1680 (neat)	199/760	—
g		6		90	1695 (KBr)	63—64	—
h		6		79	1675 (KBr)	60—61.5	61—62.5[19]
i		6		90	1725 (neat)	161/760	—
j		4		91	1690 (KBr)	64.5—65	—
k		3		96	1695 (KBr)	51.5—53.5	57—58[20]
l		3		90	1680 (KBr)	96	—
m		6		93	1705 (KBr)	85—87	—
n		6		88	1705 (KBr)	81—82.5	83—84[21]
o		3		77	1740 (KBr)	153—156	143[22]
p		3		47	1725 (KBr)	48—49	50—51[8]

a) Known products were characterized by comparison with authentic material (^1H NMR and IR spectra and mp or bp). b) Yield of isolated product. c) Melting and boiling points are all uncorrected. d) 1 Torr=133.322 Pa.

(2H, q, J=8 Hz, $C\underline{H}_2CH_3$), 6.70 (1H, s, $CHCl_2$), 7.07 (2H, d, J=8 Hz, 3,5-H_{arom}), and 7.98 (2H, d, J=8 Hz, 2,6-H_{arom}). Found: C, 55.30; H, 4.50%. Calcd for $C_{10}H_{10}OCl_2$: C, 55.33; H, 4.64%.

1-*m*-Bromophenyl-2,2-dichloro-1-ethanone (2f): Colorless oil; ^1H NMR ($CDCl_3$) δ=6.58 (1H, s, $CHCl_2$) and 7.12—8.40 (4H, m, H_{arom}). Found: C, 35.64; H, 1.95%. Calcd for $C_8H_5OBrCl_2$: C, 35.86; H, 1.88%.

1-*p*-Bromophenyl-2,2-dichloro-1-ethanone (2g): Colorless crystals; ^1H NMR ($CDCl_3$) δ=6.58 (1H, s, $CHCl_2$), 7.55 (2H, d, J=9 Hz, 3,5-H_{arom}), and 7.88 (2H, d, J=9 Hz, 2,6-H_{arom}). Found: C, 35.97; H, 1.85%. Calcd for $C_8H_5OBrCl_2$: C, 35.86; H, 1.88%.

2,2-Dichloro-1-(2,4-dichlorophenyl)-1-ethanone (2i): Colorless oil; ^1H NMR ($CDCl_3$) δ=6.88 (1H, s, $CHCl_2$) and 6.92—7.78 (3H, m, H_{arom}). Found: C, 37.32; H, 1.76%. Calcd for $C_8H_4OCl_4$: C, 37.25; H, 1.56%.

2,2-Dichloro-1-(3,4-dichlorophenyl)-1-ethanone (2j): Colorless crystals; ^1H NMR ($CDCl_3$) δ=6.50 (1H, s, $CHCl_2$) and 7.43—8.30 (3H, m, H_{arom}). Found: C, 37.46; H, 1.66%. Calcd for $C_8H_4OCl_4$: C, 37.25; H, 1.56%.

2,2-Dichloro-*p*-nitrophenyl-1-ethanone (2l): Colorless crystals; ^1H NMR ($CDCl_3$) δ=6.67 (1H, s, $CHCl_2$) and 8.28 (4H, s, H_{arom}). Found: C, 41.18; H, 2.31; N, 5.91%. Calcd for $C_8H_5NO_3Cl_2$: C, 41.06; H, 2.15; N, 5.99%.

1-(3,5-Diacetoxyphenyl)-2,2-dichloro-1-ethanone (2m): Colorless crystals; ^1H NMR ($CDCl_3$) δ=2.30 (6H, s, $OCOCH_3$), 6.60 (1H, s, $CHCl_2$), and 6.70—7.77 (3H, m, H_{arom}). Found: C, 47.19; H, 3.26%. Calcd for $C_{12}H_{10}O_5Cl_2$: C, 47.24; H, 3.30%.

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