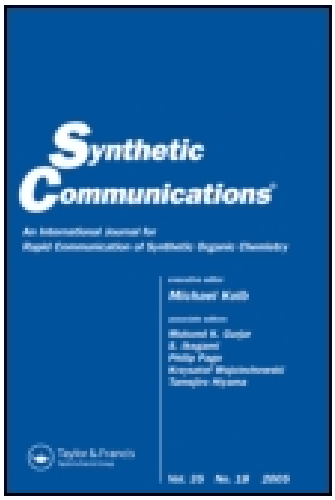

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Concomitant Desulfurization and Transesterification of Alkyl Thionocarbamates

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ABSTRACT

Alkyl carbamate (such as **1**) reacts with triphosgene at the nitrogen atom, whereas the analogous thionocarbamates (**5**) react at the sulfur. Subsequent treatment with various phenols or alcohols leads to the corresponding aryl carbamates or alkyl carbamates (**6**) respectively. The process thus involves both desulfurization and transesterification.

Key Words: Alkyl carbamate; Aryl carbamate; Thionocarbamate; Sulfur.

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INTRODUCTION

We had earlier disclosed a strategy for converting alkyl carbamates to aryl carbamates.[1–3] This was based on the use of phosphorus oxychloride in a modified Vilsmeier reaction, during which the counter ion (Cl^-), attacked the alkyl group resulting in alkyl–oxygen cleavage.

This reaction was successfully developed into a process for the industrial production of several aryl carbamate pesticides.[4] In a detailed exploration of the scope and mechanism of the reaction we have now investigated the use of reagents other than $POCl_3$ for effecting this transformation. Earlier reports in the literature have indicated that phosgene or oxalyl chloride may also bring about the conventional Vilsmeier reaction.[5,6] However the former possess serious problems in storage and handling; a better substitute would be bis(trichloromethyl)carbonate i.e., triphosgene.[7,8] We now describe the results on the reaction on alkyl carbamate such as **1** and alkyl thionocarbamates with oxygen nucleophiles in the presence of triphosgene in an attempt to extend the scope of the transesterification.

A. Reaction of Methyl N-Methyl Carbamate (1) with Triphosgene: Products Obtained on Treatment of the Complex with Phenols and Benzyl Alcohol

Methyl N-methylcarbamate (**1**) (0.089 g, 1 mmol) was treated with triphosgene (0.099 g, 0.33 mmol) and pyridine (0.079 g, 1 nmol) in dichloromethane at $-10^{\circ}C$. The resulting complex was then treated with phenol (0.094 g, 1 mmol). Purification of the crude product by column chromatography led to the isolation of a colorless liquid, which showed the presence of both an OMe and an NMe in the ^1H NMR spectrum. It was therefore not the desired phenyl N-methylcarbamate, but either (**2a**) or (**3a**). Other substituted phenols reacted similarly. The products were ultimately shown to be the aryl esters (**2**) of N-methylimidodicarbonic acid methyl ester by X-ray crystallographic analysis of the 4-bromo phenyl derivative (**2c**).[9] It was thus obvious that the ambident nucleophile (**1**) had reacted with $POCl_3$ at the oxygen,[1–3] but when the electrophilic reagent was triphosgene (or the derived phosgene analogue obtained in situ from triphosgene and pyridine)[7,8] the site of attack was the nitrogen atom (Sch. 1). Earlier, our attempt at converting methyl N-methylcarbamate (**1**) to benzyl N-methylcarbamate using $POCl_3$ as the reagent had proved abortive; the sole product obtained was benzyl chloride. The use of triphosgene instead of $POCl_3$ in this reaction again led to the attack at nitrogen, similar to the reaction with phenols as described above, to afford the bis carbamate (**4**).

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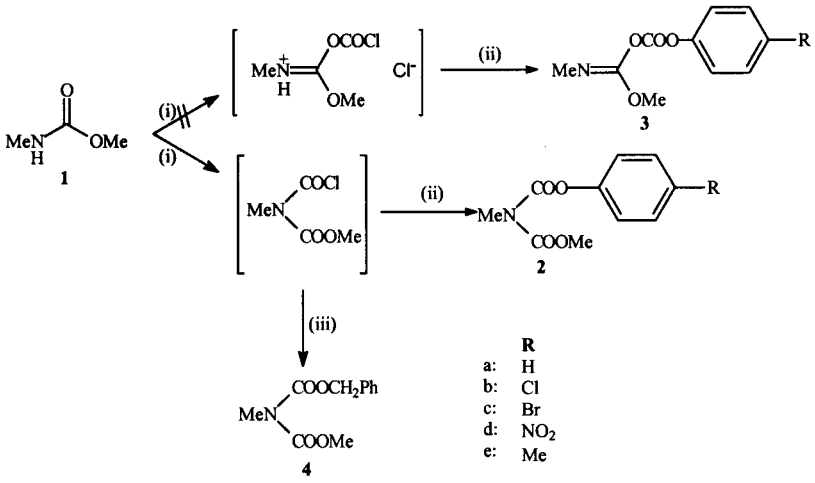
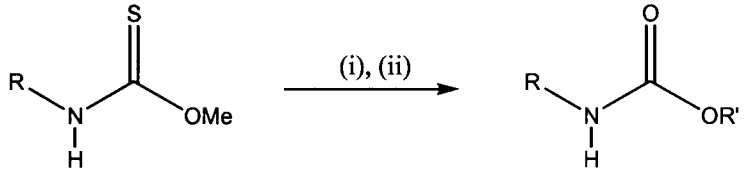


Reagents: i. Triphosgene / pyridine, CH_2Cl_2, -10°C; ii. 4-RC_6H_4OH, -10 to 30°C; iii. $PhCH_2OH$, -10 to 30°C

Scheme 1.

B. Reaction of Alkyl Thionocarbamates with Triphosgene: Transesterification with Phenols and Alcohols

It thus transpired that when triphosgene was the "Vilsmeier reagent," the initial attack on alkyl carbamates was at the nitrogen and not on the oxygen. In the hope of changing the site of electrophilic attack, it was decided to investigate the reactivity of alkyl thionocarbamates under the same conditions; it was expected that in this case, the sulfur of the thiocarbonyl group would be the preferred nucleophilic site. Earlier, it had been shown that reaction of methyl N-methylthionocarbamate (**5a**) with $POCl_3$, followed by treatment with α-naphthol, led to carbaryl in 32% yield.[1]



5 **6** (R' = alkyl or aryl)

Reagents: i. Triphosgene / pyridine, CH_2Cl_2, -10°C; ii. R'OH, -10 to 30°C; 14h

Scheme 2.

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Table 1. Carbamates from thionocarbamates.

	RNHCOOR′ (6)			
Entry no.	R	R′	Yield	Reference
1	CH_3	C_6H_5	32	[2]
2	CH_3	4-ClC_6H_4	16	[2]
3	CH_3	4-MeC_6H_4	20	[2]
4	n-Bu	C_6H_5	39	[10]
5	n-Bu	4-ClC_6H_4	54	[10]
6	n-Bu	4-MeC_6H_4	45	[11]
7	$PhCH_2$	C_6H_5	38	[10]
8	$PhCH_2$	4-ClC_6H_4	61	[10]
9	$PhCH_2$	4-MeC_6H_4	43	[12]
10	CH_3	$PhCH_2$	54	[2]
11	CH_3	$HC{\equiv}C-CH_2$	32	[13]
12	CH_3	t-Bu	68[a]	[14]
13	n-Bu	$PhCH_2$	52	[15]
14	n-Bu	$HC{\equiv}C-CH_2$	35	[16]
15	n-Bu	t-Bu	65[a]	[17]

[a]Yield by GC.

In the event, reaction of thionocarbamates with triphosgene and pyridine followed by addition of phenols afforded, after purification by columnchromatography, the corresponding aryl carbamates (**6**) as shown in Scheme 2 (entries 1–9 in Table 1). The most significant difference between $POCl_3$ and triphosgene in this series emerged during attempted transesterification of alkyl thionocarbamates with other alcohols instead of phenols.

Reaction of methyl N-methylthionocarbamate (**5a**) with $POCl_3$, followed by treatment with benzyl alcohol still resulted in the exclusive formation of benzyl chloride; no transesterified product could be detected. In contrast, thionocarbamates (**5**) (1 mmol) when treated with triphosgene (0.099 g, 0.33 mmol) and pyridine (0.079 g, 1 mmol) in dichloromethane at $-10^{\circ}C$ followed by alcohols (1 mmol), led to the desired alkyl carbamates (**6**) (entries 10–15).

EXPERIMENTAL

^1H NMR spectra were recorded in CDCl3 solution on a Bruker AC200 spectrometer at 200 MHz and chemical shifts are reported in ppm downfield from tetramethylsilane. ^{13}C NMR spectra were recorded in $CDCl_3$ solution on

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a Bruker AC 200 or MSL 300 MHz instrument. Chemical shifts are reported in ppm relative to the center line of $CDCl_3$ (77.0 ppm). Infrared spectra were recorded on a Perkin–Elmer Infracord spectrophotometer Model 599-B using sodium chloride optics. Mass spectra were recorded on a Perkin–Elmer Q-Mass 910 Mass spectrometer. Melting points were determined on a Thermonik Campbell melting point apparatus and are uncorrected. Microanalyses were performed on a Carlo-Erba CHNS-O 1108 elemental analyzer. Dichloromethane was distilled over P_2O_5 under argon and pyridine was distilled over KOH under argon. Silica gel (SD's 60–120 mesh) was used for column chromatography.

N-Methoxycarbonyl-N-phenoxycarbonyl methylamine (2a). Yield: 35%; colourless oil; ^{1}H NMR ($CDCl_3$): δ3.40 (3H, s, NCH_3), 3.85 (3H, s, OCH_3), 7.15–7.45 (5H, m, Ar); ^{13}C NMR: δ633.54, 53.73, 121.27, 125.78, 129.21, 150.59, 151.93, 153.85; IR (neat): 1760, 1700, 1590, 1490, 1450 cm^{-1}; MS (m/z, %): 209 (M^+, 0.66), 116 (10), 39 (100); Anal. Calcd. for $C_{10}H_{11}NO_4$: C, 57.41; H, 5.30; Found: C, 57.82; H, 5.20%.

N-(4-Chlorophenoxycarbonyl)-N-methoxycarbonyl methylamine (2b). Yield: 46%; mp 67°C; ^{1}H NMR ($CDCl_3$): δ3.35 (311, s, NCH_3), 3.85 (3H, s, OCH_3), 7.11 (2H, d, $J = 8.8$ Hz, Ar), 7.36 (2H, d, $J = 8.8$ Hz, Ar); ^{13}C NMR: δ33.84, 54.15, 122.87, 129.46, 131.41, 149.12, 151.99, 155.26; IR (nujol): 2900, 1750, 1720, 1440 cm^{-1}; (m/z, %): 243 (M^+, 2), 116 (16), 18 (100); Anal. Calcd. for $C_{10}H_{10}ClNO4$: C, 49.30; H, 4.14; N, 5.75; Found: C, 49.55; H, 4.22; N, 5.66%.

N-(4-Bromophenoxycarbonyl)-N-methoxycarbonyl methylamine (2c). Yield: 58%; mp 79–80°C; ^{1}H NMR ($CDCl_3$): δ3.35 (3H, s, NCH_3), 3.90 (3H, s, OCH_3), 7.05 (2H, d, $J = 9$ Hz, Ar), 7.50 (2H, d, $J = 9$ Hz, Ar); ^{13}C NMR: δ33.79, 54.05, 119.02, 123.17, 132.36, 149.63, 151.77, 153.87; IR (nujol): 2900, 1750, 1720, 1440 cm^{-1}; MS (m/z, %): 288 (M^+, 4), 116 (56), 59 (100); Anal. Calcd. for $C_{10}H_{10}BrNO_4$: C, 41.69; 11, 3.50; N, 4.86; Found: C, 41.80; 11, 3.55; N, 4.70%.

N-Methoxycarbonyl-N-(4-nitrophenoxycarbonyl) methylamine (2d). Yield: 30%; mp 75°C; ^{1}H NMR ($CDCl_3$): δ3.40 (3H, s, NCH_3), 3.90 (3H, s, OCH_3), 7.35 (2H, d, $J = 9.3$ Hz, Ar), 8.30 (2H, d, $J = 9.3$ Hz, Ar); ^{13}C NMR: δ33.80, 54.15, 122.27, 125.03, 145.31, 151.05, 153.54, 155.12; IR (nujol): 2900, 1760, 1730, 1440, 1340 cm^{-1}; MS (m/z, %): 122 ($M^+ - 132$, 0.66), 116 (8.5), 30 (100); Anal. Calcd. for $C_{10}H_{10}N_2O_6$: C, 47.25; 11,3.97; N, 11.02; Found: C, 47.16; 11,3.89; N, 10.75%.

N-Methoxycarbonyl-N-(4-methylphenoxycarbonyl) methylamine (2e). Yield: 32%; mp 58°C; ^{1}H NMR ($CDCl_3$): δ2.40 (3H, s, $ArCH_3$), 3.40 (3H, s,NCH_3), 3.90 (3H, s, OCH_3), 7.04 (2H, d, $J = 8.6$ Hz, Ar), 7.18 (2H, d, $J = 8.6$ Hz, Ar); ^{13}C NMR: δ20.52, 33.54, 53.75, 120.90, 129.67, 135.38, 148.36, 152.15, 153.95; IR (nujol): 2900, 1760, 1720, 1460 cm^{-1}; MS (m/z,

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%): 223 (M^+, 5), 116 (10), 18 (100); Anal. Calcd. for $C_{11}H_{13}NO_4$: C, 59.19; 11, 5.83; N, 6.27; Found: C, 59.19; 11, 6.00; N, 6.08%.

N-Benzyloxycarbonyl-N-methoxycarbonyl methylamine (4). Yield: 33%; colourless oil; ^{1}H VNMR ($CDCl_3$): δ 3.25 (3H, s, NCH_3), 3.84 (3H, s, OCH_3), 5.25 (2H, s, CH_2), 7.30–7.45 (5H, m, Ar); ^{13}C NMR: δ 32.97, 53.30, 67.98, 127.56, 127.87, 128.14, 135.31, 153.10, 153.79; IR (neat): 2900, 1760, 1700, 1300 cm^{-1}; MS (m/z, %): 224 ($M^+ + 1$, 0.15), 107 (0.35), 91 (100); Anal. Calcd. for $C_{11}H_{13}NO_4$: C, 59.19; 11, 5.83; N, 6.28; Found: C, 59.02; 11, 6.28; N, 6.49%.

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