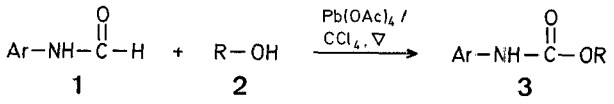
A New and Facile Synthesis of Alkyl *N*-Arylcarbamates

Rino LEARDINI*, Giuseppe ZANARDI

Istituto di Chimica Organica dell'Università, Viale Risorgimento 4, I-40136 Bologna, Italy

Although a number of good routes to carbamates are now available, alternative processes are always of interest. The method most widely employed in the synthesis of carbamates is often represented by the reaction of alcohols with isocyanates which are usually produced *in situ* from (a) acyl azides by Curtius rearrangement[1], (b) primary amines by reaction with phosgene[2], or (c) primary amides by oxidation with lead(IV) acetate[3,4].

In a previously reported work[5], we noticed that also *N*-arylformamides are able to generate isocyanates when treated with di-*t*-butyl peroxide. These results prompted us to take advantage of these amides for a new method of synthesis of carbamates which we now report. Treatment of *N*-arylformamides **(1)** with lead(IV) acetate in carbon tetrachloride solution at 78 °C in the presence of a large excess of alcohol **(2)** gives the alkyl *N*-arylcarbamates **(3)** in almost quantitative yields.



The mechanism most reasonably involves the intermediacy of isocyanates **(4)** as suggested by the reaction of **1** (Ar = 4-Cl—C_6H_4) with lead(IV) acetate carried out in the absence of alcohol in which case the isocyanate **4** (Ar = 4-Cl—C_6H_4) is isolated in rather low yields by direct distillation of the reaction mixture under reduced pressure.

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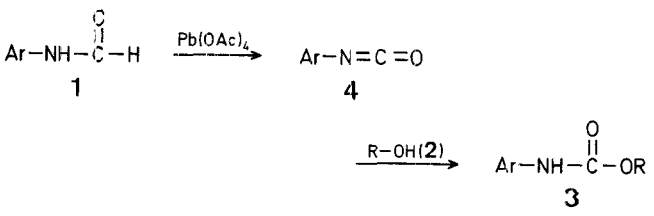

The most striking features of this method of carbamate formation are the rapidity and the simplicity of the reaction; in fact in a few minutes urethanes are formed in excellent yields and under mild conditions without isolating any by-product (Table). Furthermore, the starting *N*-arylformamides are readily accessible from commercially available amines.

However, this method suffers from the disadvantage that allyl and benzyl carbamates cannot be conveniently prepared, because, under the reaction conditions, the oxidation of allyl and benzyl alcohols appear to occur more rapidly than amide oxidation. In fact, experiments performed in the presence of allyl or benzyl alcohol give low yields of allyl carbamate and only trace amounts of benzyl carbamate, respectively, besides unreacted starting material and products arising from oxidation of the alcohols.

Carbamates were identified by mixture m.p. determination and spectral data comparison with authentic specimens. *N*-Arylformamides were prepared by the conventional method, i.e. treatment of amines with formic acid[5]. I.R. and ^{1}H-N.M.R. spectra were recorded on Perkin-Elmer 257 and Varian EM 360L instruments, respectively; mass spectra were performed with a JEOL JMS-D 100 mass spectrometer.

Alkyl *N*-Arylcarbamates 3; General Procedure:

To a solution of *N*-arylformamide **1** (10 mmol) in carbon tetrachloride (50 ml) and alcohol **2** (200 mmol), dry lead(IV) acetate (4.88 g, 11 mmol) is added at once under stirring and heating. The mixture is refluxed until the starting material disappears. The initial reddish colour fades to pale yellow when the reaction is complete. After cooling, the solvents are removed under reduced pressure and the residue is filtered through a silica gel column eluting with light petroleum ether/diethyl ether (2:1, v/v); carbamates are generally obtained in fairly good purity (≥97%). All the title compounds usually crystallize from light petroleum ether/benzene (1:1, v/v) mixtures. Results are summarized in the Table.

Ethyl *N*-Phenylcarbamate (3a):

To a hot solution of *N*-phenylformamide (**1**; Ar = C_6H_5, 1.21 g, 10 mmol) in carbon tetrachloride (50 ml) and absolute ethanol (**2**; R = C_2H_5, 9.2 g, 200 mmol), dry lead(IV) acetate (4.88 g, 11 mmol) is added under stirring. The reaction mixture is refluxed until reagent **1** disappears. After cooling, carbon tetrachloride and the excess ethanol are removed under vacuum. The residue is submitted to chromatographic filtration on a silica gel column; elution with light petroleum ether/diethyl ether (2:1, v/v) gives almost pure ethyl *N*-phenylcarbamate; yield: 1.55 g (94%). Recrystallization from light petroleum ether/benzene (1:1, v/v) gives the pure product; yield: 1.45 g (88%); m.p. 50–51 °C (Lit.[6], m.p. 51 °C).

Table. Alkyl *N*-Arylcarbamates **3a–p** prepared

Product No.	Ar	R	Reaction time	Yield[a] [%]	m.p. [°C]	Molecular formula[b] or Lit. m.p. [°C]	I.R. ($CHCl_3$) [cm^{-1}] ν_{NH}	$\nu_{C=O}$	^{1}H-N.M.R. ($CDCl_3$/TMS) δ [ppm]
3a	C_6H_5	C_2H_5	50 min	88 (94)	see experimental				
3b	C_6H_5	i-C_3H_7	50 min	90 (98)	86–87°[c]	$C_{10}H_{13}NO_2$ (179.2)	3425	1720	1.28 (d, 6H); 4.96 (sept, 1H); 6.70 (br s, 1H); 6.85–7.45 (m, 5H)
3c	C_6H_5	t-C_4H_9	50 min	87 (95)	134–135°	136°[7]	3425	1720	1.52 (s, 9H); 6.48 (br s, 1H); 6.8–7.45 (m, 5H)
3d	C_6H_5	c-C_6H_{11}	50 min	88 (96)	81–82°	82°[8]	3425	1720	1.0–2.2 (m, 10H); 4.5–5.0 (m, 1H); 6.75–7.5 (m, 6H)
3e	4-Cl—C_6H_4	C_2H_5	40 min	93 (100)	68–69°	69°[9]	3425	1720	1.25 (t, 3H); 4.15 (q, 2H); 6.77 (br s, 1H); 7.0–7.45 (m, 4H)
3f	4-Cl—C_6H_4	i-C_3H_7	40 min	87 (94)	102–104°	104°[10]	3425	1715	1.27 (d, 6H); 4.97 (sept, 1H); 6.83 (br s, 1H); 7.0–7.4 (m, 4H)
3g	4-Cl—C_6H_4	t-C_4H_9	40 min	90 (95)	105–107°	105–106°[7]	3425	1715	1.48 (s, 9H); 6.60 (br s, 1H); 7.0–7.4 (m, 4H)
3h	4-Cl—C_6H_4	c-C_6H_{11}	40 min	80 (86)	118–119°	$C_{13}H_{16}ClNO_2$ (253.7)	3425	1720	1.1–2.2 (m, 10H); 4.45–5.0 (m, 1H); 6.8–7.45 (m, 5H)
3i	4-O_2N—C_6H_4	C_2H_5	20 min	94 (100)	127–129°	129°[11]	3420	1735	1.30 (t, 3H); 4.22 (q, 2H); 7.02 (br s, 1H); 7.35–8.3 (m, 4H)
3j	4-O_2N—C_6H_4	i-C_3H_7	20 min	90 (96)	115–117°	116°[11]	3420	1730	1.30 (d, 6H); 5.00 (sept, 1H); 7.12 (br s, 1H); 7.35–8.3 (m, 4H)
3k	4-O_2N—C_6H_4	t-C_4H_9	20 min	86 (93)	108–109°	109–110°[7]	3420	1720	1.52 (s, 9H); 7.23 (br s, 1H); 7.35–8.25 (m, 4H)
3l	4-O_2N—C_6H_4	c-C_6H_{11}	20 min	84 (91)	108–109°	107–109°[12]	3420	1725	1.05–2.2 (m, 10H); 4.5–5.0 (m, 1H); 7.2–8.3 (m, 5H)
3m	3-pyridyl	C_2H_5	15 min	95 (100)	90–91°	91–92°[13]	3420	1725	1.30 (t, 3H); 4.20 (q, 2H); 7.05–8.6 (m, 4H); 8.80 (br s, 1H)
3n	3-pyridyl	i-C_3H_7	15 min	94 (100)	138–139°	137–139°[13]	3420	1720	1.28 (d, 6H); 4.98 (sept, 1H); 7.05–8.6 (m, 5H)
3o	3-pyridyl	t-C_4H_9	15 min	92 (98)	116–118°	117–118°[4]	3420	1720	1.52 (s, 9H); 7.0–8.6 (m, 4H); 8.68 (br s, 1H)
3p	3-pyridyl	c-C_6H_{11}	15 min	90 (97)	103–104°	$C_{12}H_{16}N_2O_2$ (220.3)	3420	1720	1.05–2.2 (m, 10H); 4.5–5.0 (m, 1H); 7.05–8.7 (m, 4H); 8.93 (br s, 1H)

[a] Yield of product after recrystallization; value in brackets is for crude product isolated by chromatography.
[b] Satisfactory microanalyses obtained: C ±0.05, H ±0.05, N ±0.08, Cl ±0.05.
[c] Lit.[6], m.p. 75–76 °C.

I.R. ($CHCl_3$): $\nu = 3425$ (NH), 1720 cm^{-1} (C=O).

^{1}H-N.M.R. ($CDCl_3$/TMS): $\delta = 1.25$ (t, 3H); 4.16 (q, 2H); 6.72 (br s, 1H); 6.85–7.5 ppm (m, 5H).

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