Table II. NMR Data[a]

		Chemical Shifts of Aliphatic Protons[b], δ				Chemical Shifts of Aromatic Protons[c], δ (*J*)[d]
Compd.	Solvent	CH_3O	CH_2	CHN_2	$COCH_3$	
Ib	$CDCl_3$	3.93	...	5.94	...	8.10, 7.78 (8.5)
IIb	$CDCl_3$	3.89	3.68	...	...	7.97, 7.31 (8.5)
IId	$CDCl_3$	3.89	3.64	5.21	...	7.96, 7.28 (8.5)
IIe	$CDCl_3$	3.90	3.75	...		8.02, 7.28 (8.0)
IIIb	DMS-D_6	...	3.88	...		7.91, 7.30 (8.0)

[a] All spectra run on Varian A-60 spectrophotometer. Chemical shifts given in parts per million relative to tetramethylsilane as internal standard. [b] All peaks are singlets. Relative peak areas correspond to number of protons in each group. [c] All doublets; area = 2. [d] Coupling constants (*J*) in cps. *J* values are $J_{H^2H^3} = J_{H^5H^6}$ where aromatic rings are numbered starting with carbon bearing carbomethoxy or carboxy substituent in all cases.

ACKNOWLEDGMENT

We acknowledge the assistance of Larry Echelberger.

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Received for review January 18, 1968. Accepted January 6, 1969. Investigation supported by a research grant (CA-04991) from the National Cancer Institute, Public Health Service.

Synthesis of Some Phenyl *N*-Arylcarbamates

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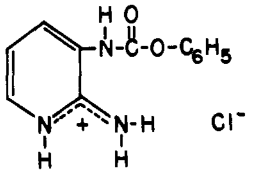
Eight phenyl *N*-(substituted phenyl)carbamates, the three isomeric phenyl *N*-pyridylcarbamates, five diphenyl *N,N′*-arylenedicarbamates, and diphenyl *N,N′*-2,6-pyridylenedicarbamate were prepared by the reaction of the appropriate amine and phenyl chloroformate. All of the new compounds were purified, characterized, and converted into derivatives, where possible. Infrared and NMR spectral data are reported, as well as some thermal data.

USING the method described by Raiford *et al.* (*8, 9*) (with minor modifications) a series of phenyl *N*-arylcarbamates was prepared by reaction of phenyl chloroformate and an aryl amine in dioxane in the presence of an acid acceptor; where tertiary amines were present as part of the molecular structure, no added base was required. To ensure completeness of reaction, stoichiometric amounts of added tertiary amine are required in the syntheses of dicarbamates which contain pyridyl or dialkylamino groups. In these latter cases, *N,N*-dimethylaniline was used as the acid acceptor. Addition of triethylamine to the mixture of hydrochlorides yielded the desired product. The reactivity of triethylamine with phenyl chloroformate (*4*) necessitated the two-step synthesis.

Reaction of excess phenyl chloroformate with 2,3-diaminopyridine produced good yields of 2(3)-amino-3(2)-carbophenoxyaminopyridine hydrochloride.



The above structure is postulated for this hydrochloride because of resonance stabilization of the cation. Analogous structures have been postulated for 2,3-diaminopyridine hydrochloride to explain its inability to form a dihydrochloride. Neutralization with a strong base yielded the cyclic 1*H*,2*H*-2-oxo-imidazolo-[4,5-*b*]pyridine (XIX).

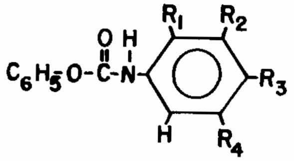
The addition of 1 mole of phenyl chloroformate to 1 mole of 2,6-diaminopyridine (in water), followed by neutralization with strong base and the subsequent addition of another mole of phenyl chloroformate, resulted in a 49% yield of 2,6-bis-(carbophenoxyamino)pyridine (XVIII). No isolation of the intermediate, 2-amino-6-carbophenoxyaminopyridine hydrochloride, was attempted.

The properties and analytical data for all of the compounds synthesized are listed in Tables I, II, and III.

The NMR spectra for each compound are in agreement with the protons of the group characteristic of the particular structure positively identified. The characteristic chemical shift, δ, for the phenyl group occurs at about 7.3 p.p.m. and exists as a multiplet. The chemical shifts and splitting patterns associated with the NH and aromatic protons are characteristic of each particular structure and also are listed in the tables.

The infrared spectra for all the phenyl carbamates investigated exhibit characteristic absorption bands as follows: medium intensity bands at 2.89 to 3.16 microns for NH; medium intensity bands at 5.65 to 5.80 microns for C=O; strong intensity bands at 6.42 to 6.57 microns for —CONH; and two bands (6.13 to 6.27, medium, and 6.65 to 6.73, strong) for the phenyl group. Other distinguishing bands peculiar to each particular structure are also present. The thermal data, including the melting range and the heats of fusion, were determined on the differential scanning calorimeter (*10*) using the Perkin-Elmer DSC-1.

Table I. Properties and Analytical Data for Phenyl *N*-Arylcarbamates



No.	Compound Substituent[a] R1	R2	R3	R4	Cryst.[b] Solv.	Yield,[c] %	Melting[d] Point, °C.	Formula	Carbon, % Calcd.	Found	Hydrogen, % Calcd.	Found	Nitrogen, % Calcd.	Found	Mol. Wt. Calcd.	Found
I	$N(CH_3)_2$[e]				D	91	145	$C_{15}H_{17}N_2O_2Cl$	61.53	61.74	5.85	6.00	9.56	9.70	292	280
II			$N(CH_3)_2$[f]		A	89	155.5–57	$C_{15}H_{16}N_2O_2$	70.31	70.20	6.25	6.35	10.94	11.09	256	260
III			$N(C_2H_5)_2$[g]		A	88	121–22[h]	$C_{17}H_{20}N_2O_2$	71.83	71.65	7.04	6.98	9.86	10.03	284	280
IV			SCH_3[i]		A	78	134–35	$C_{14}H_{13}NO_2S$	64.86	64.66	5.02	5.07	5.41	5.25	259	254
V			OCH_3[j]		A	83	156–57	$C_{14}H_{13}NO_3$	...	...	...	...	...	...	...	...
VI			OH[k]		E	90	153.5–55.5	$C_{13}H_{11}NO_3$	68.12	67.96	4.80	4.75	6.11	6.19	229	230
VII	CH_3[l]		$N(C_2H_5)_2$		C	84	114.5–15.5	$C_{18}H_{22}N_2O_2$	72.46	72.60	7.43	7.50	9.39	9.27	298	297
VIII	OCH_3		OCH_3		B	92	130–31	$C_{15}H_{15}NO_4$	65.92	66.08	5.53	5.65	5.13	5.02	273	275
IX		OCH_3	OCH_3	OCH_3	B	86	155.5–56.5	$C_{16}H_{17}NO_5$	63.36	63.25	5.65	5.80	4.62	4.72	303	308

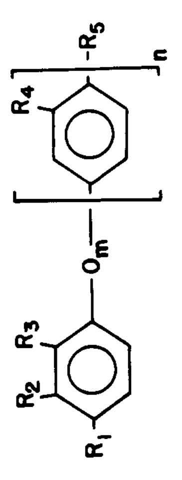
[a] Where there are no entries substituent is hydrogen. R_5 = hydrogen. [b] Solvents. A, aqueous methanol; B, absolute methanol; C, Skellysolve B; D, methylenechloride–Skellysolve B; E, chloroform. [c] In most cases crude yields reported. [d] Capillary melting points uncorrected. [e] Isolated and purified as hydrochloride (Cl, %: Calcd., 12.11; found, 12.13). [f] Picrate, m.p. 181° (dec): N, %: Calcd., 14.43; found, 14.30. [g] Picrate, m.p. 190° (dec): N, %: Calcd., 13.65; found, 13.53. [h] Benn *et al.* (*1*) report preparation of this compound from isocyanate and phenol, m.p. 125–26°. [i] S, %: Calcd., 12.36; found, 12.21. Derivative prepared by oxidizing to sulfone with $KMnO_4$: m.p. 184–85° (S, %: Calcd., 11.00; found, 10.86). [j] Prepared by method of Brunner and Wöhrl (*3*). They report m.p. 151°. [k] Preparation reported by Mack and Hobart (*7*). [l] Hydrochloride, m.p. 172–73°. Calcd. for $C_{18}H_{23}N_2O_2Cl$: C, 64.57; H, 6.92; N, 8.37; Cl, 10.59; MW, 335. Found: C, 64.42; H, 6.98; N, 8.17; Cl, 10.82; MW, 330.

Table II. Properties and Analytical Data for Phenyl *N*-Pyridylcarbamates and Diphenyl *N,N'*-Pyridylenedicarbamate

No.	Compound	Cryst. Solv.	Yield,[a] %	Melting[b] Point, °C.	Formula	Carbon, % Calcd.	Found	Hydrogen, % Calcd.	Found	Nitrogen, % Calcd.	Found	Mol. Wt. Calcd.	Found
X	2-(C_6H_5OCONH-)C_5H_4N[c]	Hexane	12	161–62	$C_{12}H_{10}N_2O_2$	67.29	67.07	4.67	4.61	13.08	12.95	214	235
XI	3-(C_6H_5OCONH-)C_5H_4N[d]	Methanol-water	90	134–37[e]	$C_{12}H_{10}N_2O_2$	67.29	67.09	4.67	4.68	13.08	13.30	214	212
XII	4-(C_6H_5OCONH-)C_5H_4N[f]	Hexane	9	142–45	$C_{12}H_{10}N_2O_2$	67.29	67.13	4.67	4.86	13.08	12.92	214	220
XVIII	2,6-(C_6H_5OCONH-)$_2C_5H_3N$[g]	Benzene	49	191–92	$C_{19}H_{15}N_3O_4$	65.32	65.35	4.33	4.36	12.03	12.08	349	358

[a] Yields of pure compound reported except for 3-isomer. [b] Capillary melting points uncorrected. [c] Picrate, m.p. 169–70° (dec.). (N, %: Calcd., 15.80; found, 15.87). [d] Hydrochloride, m.p. 295–98° (dec.). Picrate, m.p. 154° (dec.). (N, %: Calcd., 15.80; found 15.83). [e] Melting point depends on rate of heating. [f] Picrate, m.p. 175–77° (dec.). (N, %: Calcd., 15.80; found, 15.76). [g] Prepared by method of Bernstein (*2*).

Table III. Properties and Analytical Data for Diphenyl *N*,*N'*-Arylenedicarbamates



No.	Compounds[a] R₂	R₃	R₄	R₅	m	n	Cryst.[b] Solv.	Yield,[c] %	Melting[d] Point, °C.	Formula	Carbon, % Calcd.	Found	Hydrogen, % Calcd.	Found	Nitrogen, % Calcd.	Found	Mol. Wt. Calcd.	Found
XIII				R_1	0	0	C	96	243.5–44.5[e]	$C_{20}H_{16}N_2O_4$	68.97	69.08	4.60	4.81	8.05	8.12	...	...
XIV				R_1	1	1	B	93	208.5–10	$C_{26}H_{20}N_2O_5$	70.91	70.96	4.55	4.55	6.36	6.47	440	446
XV	OCH_3		OCH_3	R_1	0	1	A	94	205.5–07.5[f]	$C_{28}H_{24}N_2O_6$	69.41	69.62	4.99	5.05	5.78	5.88	484	480
XVI		R_1		CH_3	1	0	B	77	124.5–25	$C_{21}H_{18}N_2O_5$	66.67	66.87	4.76	4.90	7.41	7.20	378	371
XVII		R_1		$N(CH_3)_2$	0	0	D	12	112–13.5	$C_{22}H_{21}N_3O_4$	67.52	67.37	5.37	5.52	10.74	10.90	391	385

[a] $R_1 = C_6H_5OCONH$-. Where there are no entries in table, substituent is hydrogen. [b] A, acetone; B, acetone-water; C, nitromethane; D, Skellysolve B. [c] Crude yields reported. [d] Capillary melting points uncorrected. [e] Raiford *et al.* (8) report melting point of 238–9° C. [f] Leiser and Nischk (*6*) report diphenyl 3,3′-dimethoxy-4,4′-bicarbanilate, m.p. 208° C. from phenol and corresponding diisocyanate.

EXPERIMENTAL

All melting points are uncorrected. Analyses were by Galbraith Laboratories, Inc., Knoxville, Tenn. Using the potassium bromide wafer technique, the infrared spectra were run on the Perkin-Elmer Model 137B spectrophotometer with NaCl optics. NMR spectra were taken on the Varian A-60 and A-60A spectrometers in $CDCl_3$, using TMS as internal standard. Molecular weight determinations were run osmometrically in acetone, chloroform, ethanol, or DMF.

Phenyl *N*-Arylcarbamates. The general procedure for syntheses of neutral carbamates is as follows: To a solution of 0.1 mole of primary arylamine and 0.15 mole of organic base (*N*,*N*-dimethylaniline) in 100 ml. of dioxane was added dropwise and with mechanical stirring 0.10 mole of phenyl chloroformate in 25 ml. of dioxane. The solution was heated at reflux temperature for 2 hours, cooled, and poured into 100 ml. of 10% HCl solution. Filtration and water washing followed by drying gave a crystalline product in yields recorded in Tables I, II, and III. Recrystallization was accomplished in methanol-water.

Specialized procedures were required for monofunctional carbamates containing basic groups: Primary arylamine (0.1 mole) possessing the tertiary amino group was dissolved in 50 ml. of dioxane (or chloroform) and added dropwise to a well-stirred solution of 0.1 mole of phenyl chloroformate in 100 ml. of dioxane (chloroform) and the mixture was heated at reflux temperature for 2 hours. The solution was cooled and the product hydrochloride was filtered off, washed, and dried. To a hot solution of the above product in 5% aqueous HCl solution (5 grams per 300 ml.), 30% NaOH solution was added dropwise until one more drop did not cause a precipitate to form. Yields of crystalline product, recorded in the tables, were obtained after cooling, filtration, and washing. Recrystallization was accomplished in methanol-water.

Diphenyl *N*,*N'*-(4-Dimethylamino-*m*-phenylene)dicarbamate. Catalytic reduction of 0.1 mole of 2,4-dinitro-*N*,*N*-dimethylaniline [obtained from 2,4-dinitrochlorobenzene and dimethylamine according to the method of Campbell (5)] was accomplished by shaking its solution in 300 ml. of absolute methanol with 10% Pd-C catalyst (0.1 gram) for several hours in a Parr apparatus until no further absorption of hydrogen was evident. Removal of the catalyst and solvent yielded a brown liquid which was immediately dissolved, together with 0.1 mole of dimethylaniline, in 60 ml. of dioxane. Dropwise addition of this solution to a hot (70° C.) solution of 0.2 mole of phenyl chloroformate in 300 ml. of dioxane with rapid stirring for 2.5 hours, followed by removal of the solvent, yielded a brown tar which was then vigorously shaken in a solution of 0.1 mole of triethylamine in 300 ml. of benzene. Filtration of the cooled mixture resulted in a 93% yield of crude triethylamine hydrochloride. The tar, which remained after removal of the benzene, was subjected to a number of extractions with hot petroleum ether (b.p. 60–68° C.). On filtering and cooling, a low yield of crystalline material was obtained (Table III).

2 - Amino - 3 - Carbophenoxyaminopyridine Hydrochloride. To a stirred solution of 31.2 grams (0.20 mole) phenyl chloroformate in 200 ml. of dioxane at 80° C. was added, dropwise, a solution of 10.9 grams (0.10 mole) of 2,3-diaminopyridine and 12.1 grams (0.10 mole) of *N*,*N*-dimethylaniline in 50 ml. of dioxane. After stirring at 80° C. for 1 hour and cooling to room temperature, the crystalline product was collected, washed with dioxane, dried, and weighed (23.9 grams). Recrystallized (absolute ethanol) material melted at 262° C. (dec.). Anal. Calcd. for $C_{12}H_{12}N_3O_2Cl$: C, 54.25; H, 4.55; N, 15.82; Cl, 13.34; MW, 265. Found: C, 53.97; H, 4.65; N, 15.67; Cl, 13.43; MW, 265.

1*H*,2*H*-2-oxo-imidazolo-[4,5-*b*]pyridine (XIX). To a stirred solution of 10.0 grams of the above product in 200 ml. of water was added, dropwise, a solution of 5.0 grams of sodium acetate in 25 ml. of water while cooling with an ice bath. The precipitate of crystalline XIX (7.32 grams) was collected, washed with water, and dried. Recrystallized material (needles from water) melted at 274-75° C. Anal. Calcd. for $C_6H_5N_3O$: C, 53.33; H, 3.73; N, 31.10, MW, 135. Found: C, 53.43; H, 3.84; N, 30.92; MW, 142.

ACKNOWLEDGMENT

The authors are grateful to Nancy M. Morris for the infrared spectra and Gordon J. Boudreaux for the NMR spectra.

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RECEIVED for review February 16, 1968. Accepted January 13, 1969. NMR, IR, and thermal data are available from the authors on request. Mention of a company or a product does not imply endorsement by the U. S. Department of Agriculture to the exclusion of others which may be equally suitable.

New *N*-Alkylimides

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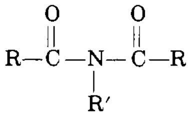
The preparation and physical properties of six new *N*-alkylimides are described. *N*-Alkylamides, which are formed as by-products in these preparations, were removed by column chromatography.

N-ALKYLIMIDES have been prepared by acylation of primary alkylamines (*4*) or *N*-alkylamides (*1*) with anhydrides in the presence of acid catalysts. A less convenient method involves the reaction of nitriles with carboxylic acids (*2*, *3*, *5*).

The authors chose to use the anhydride acylation of alkylamine hydrochlorides. In most cases *N*-alkylamides, which result as by-products, were removed by chromatography on Florisil. Purity of the *N*-alkylimides (listed in Table I) was determined by gas-liquid chromatography on a 6-mm. x 2-meter column packed with 20% Carbowax 20M on Chromosorb W. The absence of strong characteristic N-H absorption in the 3300-cm.$^{-1}$ region eliminated the likelihood of significant amounts of *N*-alkylamide con-

Table I. *N*-Alkylimides


$$R-\overset{\overset{\displaystyle O}{\|}}{C}-\underset{\underset{\displaystyle R'}{|}}{N}-\overset{\overset{\displaystyle O}{\|}}{C}-R$$

						Analysis, %[a]					
						C		H		N	
Compound	R	R′	B.P., ° C./Mm.	n_D^{20}	Empirical Formula	Calcd.	Found	Calcd.	Found	Calcd.	Found
I[b, c]	CH_3	CH_3	105–06/39[d]	1.4550	$C_5H_9NO_2$						
II	CH_3	C_2H_5	96/26[e]	1.4499	$C_6H_{11}NO_2$	55.80	56.00	8.58	8.40	10.84	10.65
III[c]	CH_3	n-C_6H_{13}	91/1–3[c]	1.4580	$C_{10}H_{19}NO_2$	64.83	65.03	10.34	10.50	7.56	7.50
IV[c]	C_2H_5	C_2H_5	114/26[d]	1.4544	$C_8H_{15}NO_2$	61.12	61.00	9.62	9.45	8.91	8.76
V[b, c]	C_2H_5	CH_3	108–10/28[f]	1.4462	$C_7H_{13}NO_2$						
VI[b]	n-C_3H_7	CH_3	133/25.5[e]	1.4567	$C_9H_{17}NO_2$						
VII[c]	n-C_3H_7	n-C_3H_7	143/24[f]	1.4532	$C_{11}H_{21}NO_2$	66.29	66.17	10.62	10.47	7.03	7.07
VIII[c]	n-C_4H_9	CH_3	103–04/1[e]	1.4586	$C_{11}H_{21}NO_2$	66.29	66.28	10.62	10.46	7.03	6.93
IX[c]	CH_3	n-C_3H_7	106–07/26[e]	1.4510	$C_7H_{13}NO_2$	58.72	58.81	9.15	9.11	9.78	9.64

[a] Elemental analyses by Galbraith Laboratories, Knoxville, Tenn. [b] See (*1*). [c] Chromatographed on Florisil. [d] Distilled through 30-cm. Oldershaw column. [e] Distilled through 30.5-cm. Scanco semimicro concentric tube column. [f] Distilled through 13-cm. Vigreux column.

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