A Convenient Preparation of 1,3-Disubstituted Dihydro-2,4-(1*H*,3*H*)pyrimidinediones

L. M. Deck* and E. P. Papadopoulos

Department of Chemistry, University of New Mexico, Albuquerque, New Mexico 87131

Received May 30, 1999

Dedicated to the memory of Professor Raymond N. Castle

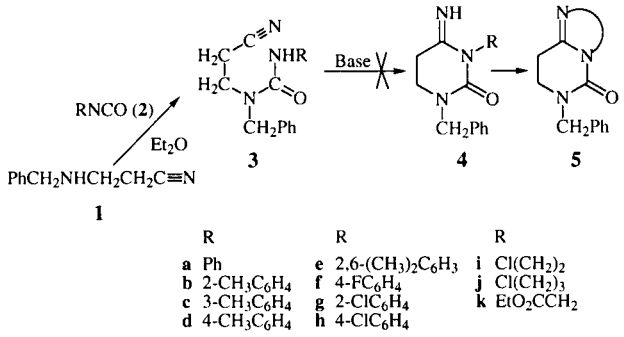
The ureas **3** which are obtained from 3-(benzylamino)propanenitrile (**1**) and various isocyanates (**2**) cyclize readily upon heating in ethanol, in the presence of hydrochloric acid, to form 3-substituted 1-benzyldihydro-2,4-(1*H*,3*H*)pyrimidinediones (**11**) in good yield.

J. Heterocyclic Chem., **37**, 675 (2000).

Aromatic *o*-aminonitriles are well established as versatile starting materials for the synthesis of a wide variety of heterocyclic compounds [1]. In particular, cyclization reactions of aromatic *o*-aminonitriles with isocyanates provide a convenient access to a number of quinazoline derivatives [2]. It was of interest to investigate analogous reactions of aliphatic 3-aminonitriles with isocyanates as a possible route to pyrimidine derivatives. In the course of this work, we became aware of a similar investigation in which 3-alkylaminopropanenitriles were treated with 2-(perfluoroalkyl)ethyl isocyanates to afford the corresponding cyanoethylureas which, upon prolonged refluxing in acetone containing a catalytic amount of hydrochloric acid, led to *N,N'*-disubstituted 2,4-(1*H*,3*H*)pyrimidinediones [3].

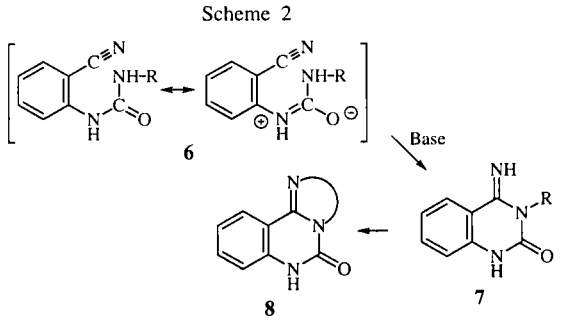
In the present work, we found that commercially available 3-(benzylamino)propanenitrile (**1**) reacted readily with isocyanates (**2a-k**) in diethyl ether, at room temperature, to give the corresponding cyanoethylureas (**3a-k**) in excellent yield (Table 1).

Scheme 1



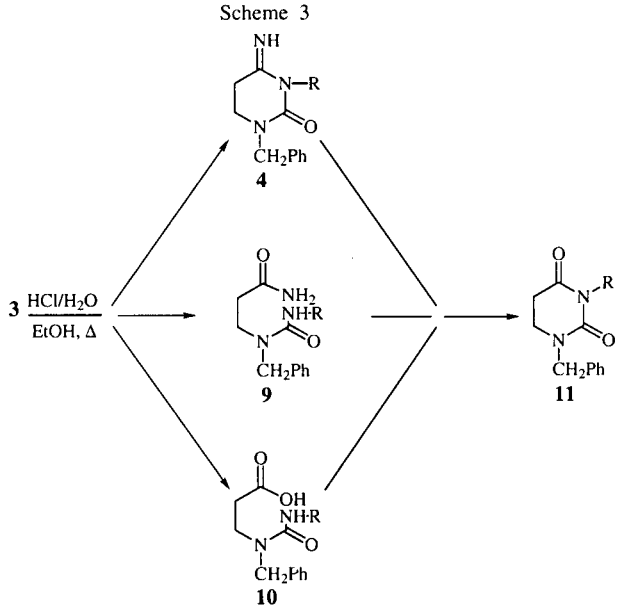
Earlier work [2] showed that cyclization of *o*-cyanoarylureas (**6**), under basic conditions, most likely involves an intramolecular nucleophilic attack by a urea nitrogen atom on the cyano group to form a cyclic imine (**7**), which was either isolated [2a,b], or presumed to be an intermediate in a second cyclization reaction to form an imidazo- or pyrimidoquinazoline ring system (**8**) [2c-f]. Based on this background, cyclization of cyanoethylureas **3** was first attempted under basic conditions with the expectation that, in the cases of **3i-k**, further cyclization of the initially formed cyclic imine **4** would result in the formation of a dihydroimidazo or tetrahydropyrimido ring fused to the

Scheme 2



original pyrimidine ring (**5**). However, although a variety of bases (triethylamine, quinoline, sodium methoxide, sodium hydride), solvents (methanol, ethanol, benzene, toluene), and temperatures (room, reflux) were used, in no case was any cyclized product (either **4** or **5**) obtained, and cyanoethylureas **3a-k** were recovered unchanged. This resistance of aliphatic cyanoethylureas **3** toward cyclization to imines under basic conditions, in contrast to the behavior of their aromatic analogs **6**, may be attributed to a number of factors, such as the lower acidity of the NH group involved in the attack on the cyano group, the weaker electrophilic character of that cyano group, and the less favorable

Scheme 3



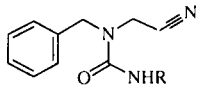
geometry for cyclization of **3** compared to **6**. Yet another factor may be the lower stability of imine **4**, with an unconjugated C=NH group, compared to imine **7**, in which that group is conjugated with the aromatic ring.

Under acidic conditions, the expected cyclizations [2c-f, 3] occurred readily. 3-Substituted 1-benzyldihydro-2,4-(1*H*,3*H*)pyrimidinediones (**11**) were obtained in good yield when cyanoethylureas **3** were refluxed in ethanol, in the presence of hydrochloric acid, for 30-60 minutes (Table 3). In the case of **11k**, better yields resulted when the refluxing period was not longer than 30 minutes to minimize hydrolysis of the ester group. It is noteworthy that these reaction times are much shorter than those found necessary (72 hours) for the analogous conversion of 2-(perfluoroalkyl)ethyl substituted cyanoethylureas to the corresponding substituted pyrimidinediones [3]. Also, when our reactions were attempted under the conditions specified in that report (reflux in acetone with a catalytic amount of hydrochloric acid), no significant conversion of cyanoethylureas **3** to pyrimidinediones **11** could be observed. The conversion of **3** to **11** may in principle involve intermediate formation of a transient imine (**4**), or hydrolysis of the cyano group to an amide (**9**), or carboxyl (**10**) group. A hypothesis that partial or complete hydrolysis of the cyano group precedes cyclization was based on the observation that a shorter reaction time (36 instead of 72 hours) was found to be effective when, instead of a cyanoethylurea, the corresponding carbamoylethylurea was used [3]. However, the experimental part of that report indicates that these two reactions were run under different conditions. Whereas the cyanoethylurea, as mentioned earlier, was refluxed in acetone with a catalytic amount of hydrochloric acid, the carbamoylethylurea was heated at 110° with a few drops of concentrated sulfuric acid [3].

In the present work, we prepared four carbamoylethylureas (**9a, c, i, j**, Table 2) by partial hydrolysis of the corresponding cyanoethylureas **3** and found that their cyclization to the respective pyrimidinediones **11** takes place readily, under conditions and with yields not substantially different from those observed for the cyanoethylureas. We also prepared carboxylic acid **10** (R = Ph, by complete hydrolysis of **1** to 3-benzylaminopropanoic acid, $PhCH_2NHCH_2CH_2CO_2H$, and subsequent reaction with phenyl isocyanate) and determined that it also cyclized to pyrimidinedione **11a**, although the reaction was slower, requiring a longer period of time (2 hours) than the cyclization of cyanoethylurea **3a**. Thus, the conversion of **3** to **11** may follow one or more pathways involving intermediates such as **4**, **9**, or **10**.

Tables 4, 5 and 6 contain ^{1}H-nmr spectroscopic data of compounds **3**, **9** and **11**, respectively. It is interesting to note that, for compounds **11a**, **c-f**, and **h-k**, the signal of the benzylic protons is a singlet, whereas in the case of **11b** and **11g** this signal appears as a doublet of doublets. This nonequivalence of the two benzylic protons should

Table 1
N-Substituted *N'*-Benzyl-*N'*-(2-cyanoethyl)ureas (**3**)



	R	Yield [a] (%)	Mp [b] (°C)	Elemental Analysis Calcd. (Found) C	H	N	IR (cm^{-1}) C=O	CN	NH
3a	C_6H_5	97	145 - 146	73.10 (73.03)	6.13 (6.28)	15.04 (14.87)	1637	2243	3310
3b	2-$CH_3C_6H_4$	92	110 - 111	73.69 (73.87)	6.53 (6.74)	14.32 (14.12)	1635	2245	3250
3c	3-$CH_3C_6H_4$	99	135 - 136	73.69 (73.75)	6.53 (6.62)	14.32 (14.33)	1640	2243	3304
3d	4-$CH_3C_6H_4$	89	126 - 127	73.69 (73.62)	6.53 (6.65)	14.32 (14.12)	1637	2246	3260
3e	2,6-$(CH_3)_2C_6H_3$	91	142 - 143	74.24 (74.51)	6.89 (7.03)	13.67 (13.66)	1630	2240	3300
3f	4-FC_6H_4	84	130 - 131	68.67 (68.60)	5.42 (5.26)	14.13 (14.22)	1636	2243	3300
3g	2-ClC_6H_4	80	87 - 88	65.07 (65.35)	5.14 (5.24)	13.39 (13.39)	1645	2255	3280
3h	4-ClC_6H_4	79	125 - 126	65.07 (65.17)	5.14 (5.25)	13.39 (13.19)	1642	2225	3285
3i	$Cl(CH_2)_2$	91	93 - 94	58.76 (58.60)	6.07 (6.07)	15.81 (15.83)	1628	2248	3314
3j	$Cl(CH_2)_3$	82	64 - 65	60.10 (59.94)	6.49 (6.52)	15.02 (15.02)	1631	2245	3315
3k	$EtOOCCH_2$	92	90 - 91	62.27 (62.31)	6.62 (6.83)	14.52 (14.53)	1634 1749	2247	3334

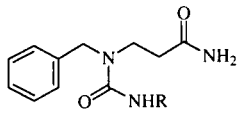
[a] Crude or recrystallized product with melting point within 10° of that of the analytically pure compound. [b]Recrystallized from ethyl acetate.

be attributed to restricted rotation about the *o*-substituted aryl-nitrogen bond, as a result of which compounds **11b** and **11g** exist as mixtures of rotational isomers. The fact that **11b** was isolated as an oil and the relatively low melting point of **11g** (compared to the other aryl-substituted **11**) are consistent with this interpretation, as is the observation that the signal of the protons alpha to the carbonyl of **11g** appears as a doublet of multiplets. There are many reports of axially twisted amides and imides exhibiting chirality due to a high rotational barrier [4].

Tables 7, 8 and 9 contain ^{13}C-nmr spectroscopic data of compounds **3**, **9** and **11**, respectively. Use of the DEPT 135-nmr experiment allowed the assignments of signals to specific carbon atoms of these compounds.

Table 2

N-Substituted *N'*-Benzyl-*N'*-(2-carbamoylethyl)ureas (**9**).

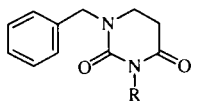


	R	Yield [a] (%)	Mp [b] (°C)	Elemental Analysis Calcd. (Found) C	H	N	C=O	IR (cm^{-1}) NH	NH
9a	C_6H_5	80	164 - 165	68.67	6.44	14.13	1640, 1670	3195	3350
			(68.55)	(6.59)	(14.11)				
9c	3-$CH_3C_6H_4$	88	135 - 136	69.43	6.80	13.49	1650, 1675	3190	3400
			(69.69)	(7.01)	(13.63)				
9i	$Cl(CH_2)_2$	78	118 - 120	55.03	6.39	14.81	1620, 1680	3225	3360
			(54.74)	(6.41)	(14.88)				
9j	$Cl(CH_2)_3$	84	130 - 131	56.47	6.77	14.11	1600, 1675	3220	3350
			(56.22)	(6.73)	(14.16)				

[a] Crude or recrystallized product with melting point within 10° of that of the analytically pure compound. [b]Recrystallized from ethyl acetate.

Table 3

3-Substituted 1-Benzyldihydro-2,4-(1*H*,3*H*)pyrimidinediones (**11**).

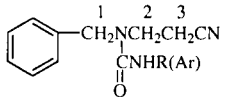


	R	Yield [a] (%)	Mp [b] (°C)	Elemental Analysis Calcd. (Found) C	H	N	IR (cmñ1) C=O
11a	C_6H_5	94	123 - 124 [c]	72.84	5.75	9.99	1725, 1687
			(72.80)	(5.74)	(9.96)		
11b	2-$CH_3C_6H_4$	70	oil [d,e]	73.45	6.16	9.52	1730, 1685
			(73.20)	(6.20)	(9.40)		
11c	3-$CH_3C_6H_4$	90	101 - 102	73.45	6.16	9.52	1728, 1670
			(73.52)	(6.32)	(9.67)		
11d	4-$CH_3C_6H_4$	82	92 - 93	73.45	6.16	9.52	1722, 1665
			(73.28)	(6.25)	(9.53)		
11e	2,6-$(CH_3)_2C_6H_3$	90	116 - 117	74.00	6.54	9.08	1730, 1675
			(74.14)	(6.81)	(8.94)		
11f	4-FC_6H_4	85	97 - 98	68.45	5.07	9.39	1730, 1672
			(68.53)	(4.88)	(9.32)		
11g	2-ClC_6H_4	82	69 - 71	64.87	4.80	8.90	1725, 1675
			(64.77)	(4.94)	(8.90)		
11h	4-ClC_6H_4	86	118 - 119	64.87	4.80	8.90	1725, 1675
			(64.81)	(4.90)	(8.80)		
11i	$Cl(CH_2)_2$	88	oil [d]	58.54	5.67	10.50	1730, 1685
			(58.31)	(5.76)	(10.28)		
11j	$Cl(CH_2)_3$	70	oil [d]	59.89	6.10	9.98	1720, 1685
			(59.65)	(6.29)	(9.73)		
11k	$EtOOCCH_2$	48	59 - 60	62.06	6.25	9.65	1750, 1676
			(62.22)	(6.22)	(9.66)		

[a] Crude or recrystallized product with melting point within 10° of that of the analytically pure compound. [b] Recrystallized from ethyl acetate. [c] Lit [5] mp 117 - 120°. [d] Purified by chromatography on silica gel using 1:1 hexane/ethyl acetate as eluant. [e] Previously reported [6] without physical description or melting point.

Table 4

^{1}H-nmr Chemical Shifts (δ) of Compounds **3a** - **3k** in Deuteriochloroform

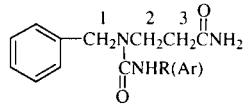


	PhH(m)	H-1(s)	H-2(t)	H-3(t)	CH_3(s)	NH(s)	Ar-H(m)	$NHCH_2$(q)	CH_2Cl(t)	OCH_2(q)	CH_2(p)
3a	6.98 - 7.44	4.68	3.74	2.74		6.38	6.98 - 7.44				
3b	7.03 - 7.43	4.74	3.83	2.82	1.74	6.10	7.03 - 7.43				
3c	6.82 - 7.44	4.68	3.75	2.75	2.28	6.32	6.82 - 7.44				
3d	7.00 - 7.42	4.64	3.68	2.68	2.26	6.44	7.00 - 7.42				
3e	7.30 - 7.48	4.71	3.76	2.73	2.00	5.76	6.98 [a]				
3f	6.88 - 7.46	4.68	3.73	2.73		6.39	6.88 - 7.46				
3g	6.91 - 7.45	4.71	3.77	2.75		6.91	6.91 - 7.45 [b]				
3h	7.10 - 7.43	4.68	3.74	2.74		6.41	7.10 - 7.43				
3i	7.21 - 7.42	4.57	3.67	2.68		4.92 [c]		3.58	3.49		
3j	7.18 - 7.45	4.55	3.67	2.67		4.67 [c]		3.32	3.41		1.89
3k	7.24 - 7.43	4.59	3.65	2.67	1.26 [c]	5.03 [c]		3.94 [d]		4.16	

[a] Broad singlet; [b] doublet at 8.10 for one Ar-H; [c] triplet; [d] doublet.

Table 5

^{1}H-nmr Chemical Shifts (δ) of Compounds **9** in Dimethyl-d_6 Sulfoxide

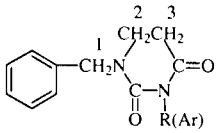


	PhH(m)	H-1(s)	H-2(t)	H-3(t)	CH_3(s)	NH(s)	Ar-H(m)	$NHCH_2$(q)	CH_2Cl(t)	CH_2(p)	NH_2
9a	6.88 - 7.58	4.51	3.47	2.41		9.17	6.88 - 7.58				6.88 - 7.58
9c	6.71 - 7.59	4.49	3.46	2.41	2.23	9.14	6.71 - 7.59				6.71 - 7.59
9i	6.92 - 7.42	4.44	3.32	2.31	6.94 [a]			3.36	3.60		6.92 - 7.42
9j	6.91 - 7.42	4.41	3.31	2.28	6.68 [a]			3.15	3.61	1.86	6.91 - 7.42

[a] Triplet.

Table 6

^{1}H-nmr Chemical Shifts (δ) of Compounds **11a** - **11k** in Deuteriochloroform



	PhH(m)	H-1(s)	H-2(t)	H-3(t)	CH_3(s)	Ar-H(m)	NCH_2(t)	CH_2Cl(t)	OCH_2(q)	CH_2(p)
11a	7.18 - 7.46	4.65	3.42	2.81		7.18 - 7.46				
11b	7.10 - 7.37	4.67 [a]	3.43	2.83	2.15	7.10 - 7.37				
11c	6.98 - 7.37	4.66	3.43	2.82	2.38	6.98 - 7.37				
11d	7.05 - 7.34	4.63	3.37	2.77	2.36	7.05 - 7.34				
11e	7.10 - 7.37	4.68	3.43	2.84	2.13	7.10 - 7.37				
11f	7.08 - 7.40	4.64	3.41	2.79		7.08 - 7.37				
11g	7.24 - 7.51	4.67 [a]	3.43 [b]	2.82		7.24 - 7.51				
11h	7.10 - 7.41	4.62	3.37	2.77		7.10 - 7.41				
11i	7.26 - 7.37	4.64	3.30	2.68			3.70	4.19		
11j	7.26 - 7.36	4.63	3.28	2.65			3.58	3.97		2.09
11k	7.26 - 7.40	4.64	3.35	2.72	1.28 [c]		4.57 [d]		4.20	

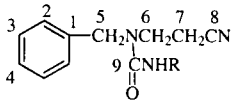
[a] 4.58, 4.76 doublet of doublets; [b] doublet of multiplets; [c] triplet; [d] singlet.

EXPERIMENTAL

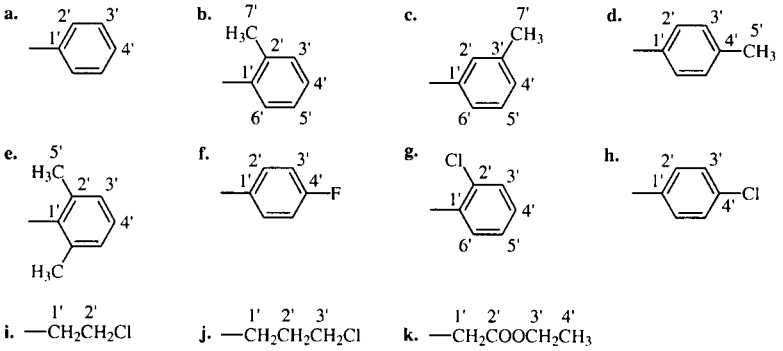
Reagent-grade solvents were used without further purification. Ethyl ether was distilled from calcium hydride. Melting points were determined in capillaries with a Thomas-Hoover Uni-Melt apparatus and are uncorrected. Infrared spectra were recorded on a Beckman IR-33 spectrophotometer using mineral oil mulls. Proton and carbon-13 nmr spectra were obtained on a Bruker AC250 nmr spectrometer. Chemical shifts are in ppm (δ) relative to internal tetramethylsilane.

Table 7

^{13}C-nmr Shifts of Compounds **3a** - **3k** in Deuteriochloroform.



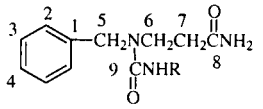
R

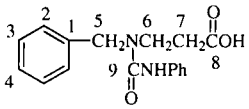


	1	2	3	4	5	6	7	8	9	1'	2'	3'	4'	5'	6'	7'
3a	138.3	126.4	129.3	128.2	52.4	45.1	17.2	118.5	155.2	136.0	120.2	128.7	123.5			
3b	136.3	126.1	129.3	128.3	52.9	46.0	17.5	118.5	155.3	135.9	128.4	130.1	122.4	126.5	124.0	17.1
3c	138.5	126.4	129.1	128.4	52.1	44.7	17.1	118.4	155.3	138.2	120.9	136.1	124.2	128.0	117.3	21.3
3d	136.1	126.4	129.2	128.0	52.2	44.8	17.1	118.5	155.4	135.6	120.5	129.1	133.0	20.6		
3e	136.4	126.2	129.2	128.2	53.0	45.8	17.5	118.5	155.4	135.0	134.5	128.0	126.5	18.2		
3f	135.9	126.3	129.2	128.2	52.1	44.8	17.1	118.4	155.4	134.1	122.3	115.3	159.0			
3g	135.3	126.2	129.2	128.2	52.8	45.6	17.3	118.2	154.5	135.2	122.5	128.6	123.4	127.4	121.0	
3h	136.8	126.2	129.3	128.3	52.5	45.3	17.3	118.3	154.9	135.6	128.6	121.2	128.4			
3i	136.1	126.3	129.1	127.9	51.9	44.7	17.2	118.4	157.3	44.3	42.4					
3j	136.3	126.1	129.1	127.9	52.2	45.1	17.5	118.4	157.5	38.2	32.4	42.5				
3k	136.2	126.3	128.4	127.2	50.7	43.2	16.4	118.0	157.2	42.1	170.3	60.6	13.6			

Table 8

^{13}C-nmr Shifts of Compounds **9** in Dimethyl-d_6 Sulfoxide and Compound **10** in Deuteriochloroform





	1	2	3	4	5	6	7	8	9	1'	2'	3'	4'	5'	6'	7'
9a	138.7	127.3	128.4	126.9	48.9	42.5	33.9	174.1	155.6	140.7	119.2	128.4	121.6			
9c	138.7	127.3	128.4	126.9	48.9	42.4	33.8	174.0	155.5	140.6	119.7	137.4	122.2	128.2	116.3	21.2
9i	138.9	127.2	128.3	126.8	48.9	43.7	33.9	173.0	157.4	42.2	42.3					
9j	139.1	127.1	128.3	126.7	48.8	43.2	33.9	173.2	157.7	37.7	32.9	42.2				
10	138.7	127.3	128.5	127.0	49.3	42.4	32.9	173.6	155.3	140.5	119.9	128.3	121.9			

N-Substituted *N'*-Benzyl-*N'*-(2-cyanoethyl)ureas (**3**).

To 0.010 mole of 3-(benzylamino)propanenitrile (**1**) in 10 ml of anhydrous ethyl ether was added 0.011 mole of the isocyanate (**2**) in 5 ml of anhydrous ethyl ether dropwise with stirring. An exothermic reaction took place and a solid precipitated. The mixture was allowed to stand for one hour and the precipitate was collected by filtration. Yields and physical properties of compounds **3** are shown in Table 1.

N-Substituted *N'*-Benzyl-*N'*-(2-carbamoylethyl)ureas (**9**).

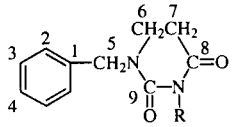
A solution of 1.0 g of the substituted urea **3** in 10 ml of concentrated hydrochloric acid, obtained by warming if necessary, was stirred at room temperature for 1 hour. Addition of ice and scratching with a glass rod caused precipitation of a solid which was collected by filtration and was recrystallized from ethyl acetate. Yields and physical properties of compounds **9** are shown in Table 2.

N-Benzyl-*N*-phenylcarbamoyl-3-aminopropanoic acid (**10**).

A mixture of 3-(benzylamino)propanenitrile (**1**) (1.6 g, 0.010 mole) and 10 ml of 10% aqueous sodium hydroxide was heated under reflux for 1 hour. After cooling, phenyl isocyanate (1.2 g, 0.011 mole) was added and the resulting mixture was stirred at room temperature for 30 minutes and then filtered. The chilled filtrate was acidified with concentrated hydrochloric acid to

Table 9

^{13}C-nmr Shifts of Compounds **11a** - **11k** in Deuteriochloroform.



	1	2	3	4	5	6	7	8	9	1'	2'	3'	4'	5'	6'	7'
11a	136.1	128.1	128.9	127.8	51.6	40.4	32.0	169.0	153.6	135.5	128.6	128.7	128.2			
11b	136.2	127.9	128.6	127.7	51.5	40.5	31.9	168.6	153.1	135.7	134.8	130.5	128.7	126.5	128.5	17.4
11c	136.2	128.1	128.7	127.8	51.6	40.4	32.1	169.0	153.7	135.4	129.2	138.8	129.1	125.6	128.7	21.3
11d	136.2	128.1	128.7	127.8	51.6	40.4	32.1	169.1	153.7	135.4	129.6	128.3	138.8	21.3		
11e	136.3	128.1	128.6	127.7	51.5	40.6	31.8	168.1	152.6	135.5	134.0	127.9	128.3	17.7		
11f	136.0	127.9	128.6	127.7	51.4	40.1	31.7	169.0	153.4	131.4	130.4	115.7	161.9			
11g	136.0	127.9	128.7	127.8	51.5	40.5	31.9	168.4	152.7	133.5	132.7	130.7	129.7	129.8	127.4	
11h	136.0	128.0	128.7	127.9	51.6	40.3	31.9	168.8	153.2	134.0	130.1	129.0	133.9			
11i	136.0	127.7	128.7	127.8	51.5	41.6	31.5	168.8	153.2	40.3	41.1					
11j	136.2	127.8	128.6	127.7	51.5	40.2	31.5	168.8	153.5	38.9	31.4	42.6				
11k	136.0	127.8	128.7	127.7	51.6	40.2	31.3	168.3	153.2	41.9	168.7	61.3	14.1			

yield 1.5 g (50%) of **10**. Recrystallization from ethyl acetate gave the pure compound, mp 113-114°; ir: 3290 (NH), 1735, 1615 (C=O) cm^{-1}; ^{1}H-nmr: δ 2.62 (t, 2H, CH_2COOH), 3.62 (t, 2H, NCH_2), 4.55 (s, 2H, $PhCH_2$), 6.96-7.34 (m, 10H, ArH), 7.79 (s, 1H, NH), 10.2 (s, 1H, COOH).

Anal. Calcd. for $C_{17}H_{18}N_2O_3$: C, 68.44; H, 6.08; N, 9.39. Found: C, 68.35; H, 6.21; N, 9.30.

3-Substituted 1-Benzyldihydro-2,4-(1*H*,3*H*)pyrimidinediones (**11**).

A mixture of 1.0 g of the substituted urea **3**, 10 ml of ethanol and 5 ml of concentrated hydrochloric acid was heated under reflux for 30-60 minutes. After cooling, the solution was diluted with water and the precipitated solid was collected by filtration. Liquid products (**11b**, **11i**, **11j**) were isolated by extraction with ethyl acetate and purified by chromatography on silica gel using 1:1 hexane/ethyl acetate as the eluant. Yields and physical properties of compounds **11** are shown in Table 3.

REFERENCES AND NOTES

[1] E. C. Taylor and A. McKillop, "The Chemistry of Cyclic Enaminonitriles and *o*-Aminonitriles," Interscience, New York, NY, 1970.

[2a] K. W. Breukink and P. E. Verkade, *Rec. Trav. Chim.*, **79**, 443 (1960); [b] E. C. Taylor and R. V. Ravintranathan, *J. Org. Chem.*, **27**, 2622 (1962); [c] E. P. Papadopoulos, *J. Heterocyclic Chem.*, **17**, 1553 (1980); [d] E. P. Papadopoulos, *J. Heterocyclic Chem.*, **18**, 515 (1981); [e] E. P. Papadopoulos, *J. Heterocyclic Chem.*, **21**, 1411 (1984); [f] J. Petridou-Fischer and E. P. Papadopoulos, *J. Heterocyclic Chem.*, **21**, 1333 (1984).

[3] M. A. Jouani, H. Trabelsi, F. Szönyi, and A. Cambon, *Bull. Soc. Chim. France*, **133**, 839 (1996).

[4] D. P. Curran, H. Qi, S. J. Geib, and N. C. DeMello, *J. Am. Chem. Soc.*, **116**, 3131 (1994).

[5] P. Adams and B. Juliano, U.S. Patent 3,422,108 (1969); *Chem. Abstr.*, **70**, P68409r (1969).

[6] S. A. Kolodziej and B. C. Hamper, *Tetrahedron Letters*, **37**, 5277 (1996).