

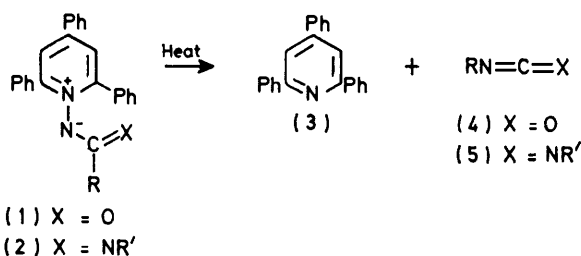
Heterocycles in Organic Synthesis. Part 24.¹ A New Synthesis of *NN'*-Diarylcarbodi-imides²

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Amidrazones react with pyrylium salts to give pyridine imidoyl-*N*-imines, the pyrolysis of which forms the corresponding diarylcarbodi-imide in high yield.

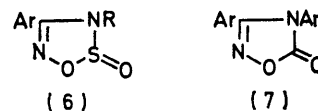
Pyrolysis of 2,4,6-triphenylpyridine acyl-*N*-imides (1) occurs in good yield to give 2,4,6-triphenylpyridine (3) and isocyanate (4).³ We now report that the pyrolysis of the analogous imidoyl-*N*-imides (2) provides a useful synthesis of symmetrical and unsymmetrical *NN'*-diarylcarbodi-imides (5).



Carbodi-imides are of considerable importance in synthesis, both in the preparation of numerous urea derivatives and heterocycles, and also as dehydrating agents to cause acylation, particularly in peptide synthesis.⁴ Previous synthetically useful preparations⁵ of carbodi-imides include the elimination of hydrogen sulphide from thioureas, dehydration of ureas, pyrolysis of *S*-alkylisothiureas, and the catalytic conversion of isocyanates. Interest in new procedures remains and thus recent papers have described the use of butyllithium⁶ and 2-chloro-1-methylpyridinium cation⁷ to eliminate hydrogen sulphide from thioureas.

The foregoing methods all convert *amine* derivatives into carbodi-imides. A group of reactions does exist which involves their preparation from *carboxylic acid* derivatives, although these appear in general of minor synthetic utility, with the exception of the thermolysis of 1,2,3,5-oxathiadiazole 2-oxides (6) which give under mild conditions aliphatic and aromatic carbodi-imides in good

yield.⁸ Thus the pyrolysis of 1,5-diaryltetrazoles⁹ in practice is limited to the preparation of *symmetrical* diarylcarbodi-imides, for the temperature and time of heating required causes extensive disproportionation of unsymmetrical carbodi-imides thus resulting in a mixture of products. Pyrolysis of 1,2,4-oxadiazol-5-ones (7) also gives significant quantities of by-products,¹⁰ and although the thia-analogues (6) thermolyse to give carbodi-imides in good yield,^{8,11} the preparation of (6) may require the use of difficultly accessible intermediates. Other related reactions, of more mechanistic than preparative importance, involve the conversion of amidoximes by benzenesulphonyl chloride¹² or phosphorus oxychloride¹³ and the reaction of *N*-chloro-*N'*-phenylbenzimidine with silver oxide.¹⁴



Preparation of Imidoyl-N-imides (2).—Storr and his co-workers prepared¹⁵ imidoyl-*N*-imides (10) in the benzocinnolinium series by reaction of benzocinnoline *N*-imide (8) with imidoyl chlorides (9), and a Japanese group¹⁶ has made (11) by reaction of 1-aminopyridinium iodide with ethyl *N*-ethoxycarbonylbenzimidate. We now find that amidrazones (12) (Table 1) react smoothly with 2,4,6-triphenylpyrylium perchlorate (13) in ethanol to give high yields of the salts (14) (Table 2). These cations possess another tautomeric structure (15), but previous work¹⁷ on the tautomerism of amidines suggests that (14) should greatly predominate. The amidrazones (12) were prepared from the corresponding thioamides¹⁸ by standard procedures.¹⁹ The salts (14) are readily deprotonated to the imidoyl-*N*-imides (2) (Table 3) by methanolic potassium hydroxide.

TABLE I
Preparation of amidrazones (12)

R	R'	M.p. (°C)	Crystal form	Mol. formula	Found (%)			Required (%)		
					C	H	N	C	H	N
Ph	Ph	90—91 ^a	Needles							
Ph	MeC ₆ H ₄ (<i>p</i>)	100—101 ^b	Needles							
Ph	ClC ₆ H ₄ (<i>p</i>)	94—96	Needles	C ₁₃ H ₁₂ ClN ₃	63.1	5.0	17.4	63.5	4.9	17.1
Ph	MeOC ₆ H ₄ (<i>p</i>)	99—101	Prisms	C ₁₄ H ₁₅ N ₃ O	69.1	6.3	17.2	69.7	6.2	17.4
Ph	MeC ₆ H ₄ (<i>o</i>)	87—90	Prisms	C ₁₄ H ₁₅ N ₃	74.3	6.6	18.6	74.7	6.7	18.7
Ph	ClC ₆ H ₄ (<i>o</i>)	84—86	Needles	C ₁₃ H ₁₂ ClN ₃	63.3	4.9	17.2	63.7	4.9	17.1
MeC ₆ H ₄ (<i>p</i>)	Ph	95—97	Needles	C ₁₄ H ₁₅ N ₃	74.1	6.6	18.4	74.7	6.7	18.7
Ph	2,4,6-Me ₃ C ₆ H ₂	71—73	Needles	C ₁₆ H ₁₉ N ₃	76.1	7.9	16.1	75.9	7.6	16.6
Pyridyl-(4)	Ph	74—76	Needles	C ₁₂ H ₁₂ N ₄	67.6	5.9	26.9	67.9	5.7	26.4

^a Lit. m.p. 90—92 °C, ref. 19a. ^b Lit. m.p. 101—103 °C, ref. 19b.

TABLE 2
Preparation of pyridinium perchlorates (14)

R	R'	Yield (%)	M.p. (°C)	Crystal form	Mol. formula	Found (%)			Required (%)		
						C	H	N	C	H	N
Ph	Ph	92	250—255	Prisms	C ₃₆ H ₂₆ ClN ₃ O ₄	71.5	4.7	7.0	71.8	4.6	6.9
Ph	MeC ₆ H ₄ (<i>p</i>)	89	152—155	Prisms	C ₃₇ H ₃₀ ClN ₃ O ₄	71.7	4.9	6.5	72.1	4.8	6.8
Ph	ClC ₆ H ₄ (<i>p</i>)	90	207—210	Prisms	C ₃₆ H ₂₇ Cl ₂ N ₃ O ₄			6.6			6.6
Ph	MeOC ₆ H ₄ (<i>p</i>)	90	215—218	Prisms	C ₃₇ H ₃₀ ClN ₃ O ₅			7.1			6.7
Ph	MeC ₆ H ₄ (<i>o</i>)	93	281—285	Prisms	C ₃₆ H ₃₀ ClN ₃ O ₄	71.7	4.9	6.7	72.1	4.8	6.8
Ph	ClC ₆ H ₄ (<i>o</i>)	90	259—263	Prisms	C ₃₆ H ₃₀ Cl ₂ N ₃ O ₄	67.5	4.6	6.3	67.9	4.2	6.6
MeC ₆ H ₄ (<i>p</i>)	Ph	85	145—150	Prisms	C ₃₇ H ₃₀ ClN ₃ O ₄	72.6	4.6	6.9	72.1	4.9	6.8
Ph	2,4,6-Me ₃ C ₆ H ₂	88	278—280	Needles	C ₃₉ H ₃₄ ClN ₃ O ₄	72.2	5.2	6.7	72.7	5.3	6.5
Pyridyl-(4)	Ph	94	268—270	Prisms	C ₃₅ H ₂₇ ClN ₄ O ₄	69.3	4.7	9.1	69.7	4.5	9.3

TABLE 3
Preparation and pyrolysis of imidoylimides (2)

R	R'	Yield		Crystal form	Crystallisation solvent	Mol. formula	Found (%)			Required (%)			Carbodi-imides yield (%)	Ureas		Ref.
		(°C)	(°C)				C	H	N	C	H	N		M.p. (°C)	Lit. m.p. (°C)	
Ph	Ph	87	120—123	Prisms	Benzene	C ₉ H ₂₂ N ₃			8.4			8.3	86	231—235	239—240	
Ph	MeC ₆ H ₄ (<i>p</i>)	92	122—125	Prisms	Benzene	C ₉ H ₂₀ N ₃			8.0			8.2	96	210—214	217—218	
Ph	ClC ₆ H ₄ (<i>p</i>)	85	116—119	Prisms	Benzene	C ₉ H ₂₀ ClN ₃			7.5			7.8	95	230—234	240	<i>a</i>
Ph	MeOC ₆ H ₄ (<i>p</i>)	87	83—85	Prisms	MeOH	C ₉ H ₂₂ N ₃ O			7.7			7.9	95	182—184	193—194	<i>a</i>
Ph	MeC ₆ H ₄ (<i>o</i>)	90	196—198	Prisms	Benzene	C ₉ H ₂₂ N ₃	85.5	5.4	8.1	86.2	5.6	8.1	92	196—198	196	<i>b</i>
Ph	ClC ₆ H ₄ (<i>o</i>)	92	204—206	Prisms	Benzene	C ₉ H ₂₀ ClN ₃	80.5	5.1	7.5	80.6	4.8	7.8	95	179—181	181—182	<i>c</i>
Ph	2,4,6-triMeC ₆ H ₂	96	197—199	Needles	Benzene	C ₉ H ₂₄ N ₃	86.6	6.0	7.6	86.2	6.1	7.7	92	234—236	236—237	<i>a</i>
MeC ₆ H ₄ (<i>p</i>)	Ph	94	107—109	Prisms	Benzene	C ₉ H ₂₂ N ₃	86.0	5.8	8.0	86.2	5.7	8.1	85	210—211	217—218	<i>a</i>
Pyridyl-(4)	Ph	96	137—141	Prisms	MeOH	C ₉ H ₂₄ N ₄	83.4	5.4	11.3	83.6	5.2	11.1				

^a Ref. 8. ^b Beilsteins Handbuch der Organischen Chemie, eds. B. Prager, P. Jacobson, P. Schmidt, and D. Stern, Vol. 12, Verlag von Julius Springer, Berlin, 1929, p. 801. ^c *Ibid.*, p. 601.

Pyrolysis of Imidoyl-N-imides.—The thermolyses of both the previously described types of imidoyl-*N*-imide (10) and (11) involve participation of the heterocyclic ring. The cinnoline derivatives (10) yield¹⁵ *N*-substituted cinnoline-*N*-imides by extrusion of PhCN. The

pyridine (3) and the carbodi-imide (5) (Table 3). The carbodi-imides were characterised by their i.r. spectra and by qualitative conversion into the corresponding ureas by water.

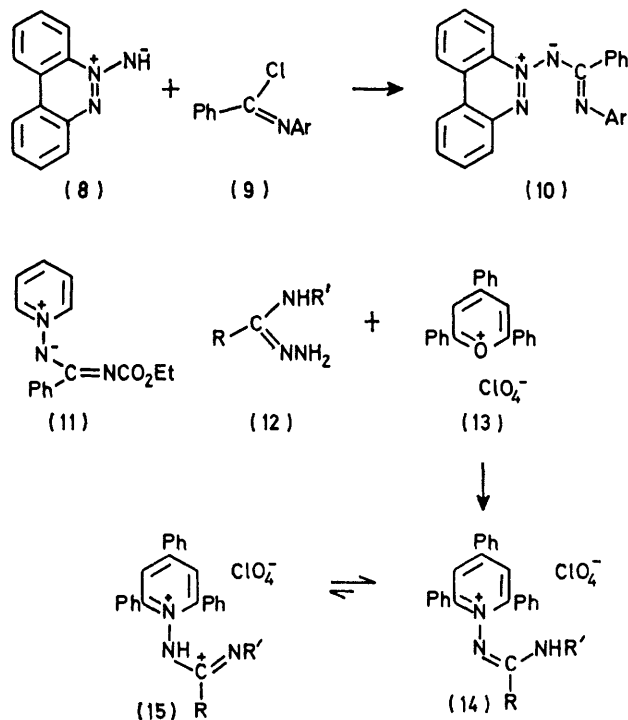
EXPERIMENTAL

Thioamides RC(S)·NHR', from which the amidrazones were prepared, were obtained by sulphurisation of the corresponding amides with P₄S₁₀ in pyridine and showed characteristics identical to those in the literature.¹⁸ *N*-Mesitylbenzothioamide, not previously described, had m.p. 162—163 °C (from methanol-water); δ(CDCl₃) 2.16 (9 H), 2.27 (3 H), 6.87 (2 H), 7.30—7.80 (5 H), and 8.6 (1 H); *m/e* 255 (M⁺), 240 (M - CH₃)⁺, 223 (M - S)⁺, and 121 (C₆H₅CS)⁺.

Preparation of Amidrazones (12) (cf. ref. 19).—The thioamide (0.005 mol) in ethanol (15 ml) was treated with hydrazine hydrate (98%) (1.5 ml) and the reaction mixture was stirred at 20 °C, or heated under reflux, until evolution of hydrogen sulphide had ceased (10 min—2 h). The mixture was cooled and water (ca. 50 ml) was added to precipitate the product, which was crystallised from ethanol; yields were 60—80%. All amidrazones (12) (Table 1) showed typical i.r. absorptions in the range 3 500—3 300 (NH and NH₂) and at ca. 1 600 cm⁻¹ (C=N). Mass spectra showed in addition to the parent peak M⁺, peaks corresponding to the loss of N·NH₂ and NHR'.

1-Amidino-2,4,6-triphenylpyridinium Perchlorates (14).—2,4,6-Triphenylpyrylium perchlorate²⁰ (4.08 g, 0.01 mol) and the amidrazone (0.012 mol) were stirred in ethanol (50 ml) 12 h at 20 °C. The separated salt was crystallised from ethanol (Table 2).

2,4,6-Triphenylpyridine Imidoyl-N-imines (2).—KOH (0.005 5 mol) in MeOH (20 ml) was added with stirring at 20 °C to the 1-amidino-2,4,6-triphenylpyridinium perchlorate (0.005 mol) in MeOH (100 ml). The pH value should reach 9. The MeOH was removed at 40 °C/12—15 mmHg. Water (50 ml) and CHCl₃ (100 ml) were then



simple pyridine derivative (11) gave a mixture of a bicyclic pyridotriazole and pyridotriazine.¹⁶

By contrast our 2,4,6-triphenylpyridine imidoyl-*N*-imides (2) thermolysed cleanly to 2,4,6-triphenyl-

added. The dried (MgSO_4) chloroform layer was evaporated at $40^\circ\text{C}/12\text{--}15\text{ mmHg}$ and Et_2O (15 ml) added to give the *N-imine*, which was recrystallised from the appropriate solvent (Table 3).

Pyrolysis of 2,4,6-Triphenylpyridine Imidoyl-N-imines.—The imidoylimine was dried at $90^\circ\text{C}/0.5\text{ mmHg}$ for 5 h. The pyrolysis was carried out at $0.2\text{--}0.5\text{ mmHg}$ and at $150\text{--}200^\circ\text{C}$; the corresponding carbodi-imide (90—95%) distilled off, and was characterised by i.r. spectroscopy. Reaction with water gave the corresponding urea which was identified by its i.r. spectrum and m.p.

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