Studies of Enamines. II.[1] The Reaction of 4-(1-Piperidyl)- and 4-(1-Pyrrolidinyl)-3-penten-2-ones with Aryl Isocyanates

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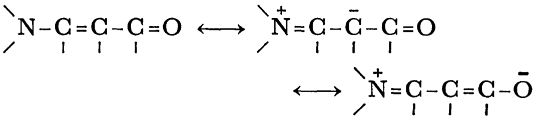
The reaction of aryl isocyanates with enamino ketones, derived from acetylacetone and secondary amines such as piperidine and pyrrolidine, has been investigated. At room temperature, enamino ketones react with phenyl, *p*-chlorophenyl and *p*-tolyl isocyanate to give 1: 2 adducts, 3,5-diarylcarbamoyl derivative. In solution, these adducts exist in general as a mixture of two tautomers, 3-penten-2-one and 4-penten-2-one, the ratio depending on the solvent. Under reflux in benzene, the reaction of enamino ketones with phenyl isocyanate gives 4-amino-6-methyl-1-phenyl-5-phenylcarbamoylpyrid-2-one and its 3-phenylcarbamoyl derivative; the former is also obtained by heating the 1: 2 adduct. On the other hand, 4-(1-pyrrolidinyl)-3-penten-2-one reacts with 1-naphthyl isocyanate to afford the 1: 1 adduct, 5-(1-naphthylcarbamoyl)-4-penten-2-one.

Many investigations have been carried out on the reactions of enamines with isocyanates. Products of different types are formed depending on the structures of the enamines and on the reaction conditions. For example, the reaction of β-disubstituted enamines with phenyl isocyanate at low temperature gives β-amino-β-lactams,[3,4] while the reaction with two equivalents of the isocyanate at high temperature affords hydrouracils, the 1: 2 cycloadducts.[5] On the other hand, enamines having β-hydrogen react with isocyanates to give the corresponding carboxamides.[6,7]

Although a few reports are available on the reactions of enamino ketones with electrophiles,[8–11] the reaction of enamino ketones with isocyanates has not been investigated. On the basis of previous studies,[8–11] the chemical behavior of enamino ketones can be understood in terms of the following mesomeric forms.



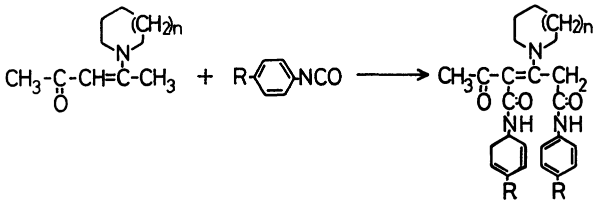
$$\rangle N-C=C-C=O \longleftrightarrow \rangle\overset{+}{N}=C-\overset{-}{C}-C=O \longleftrightarrow \rangle\overset{+}{N}=C-C=C-\overset{-}{O}$$

It thus appeared of interest to investigate the reaction of enamino ketones with isocyanates. We report on a new reaction of enamino ketones derived from acetylacetone with aryl isocyanates.

Results and Discussion

Reaction at Room Temperature. When 4-(1-piperidyl)-3-penten-2-one (Ia) was treated with two equivalents of phenyl isocyanate (IIa) in benzene at room temperature for 5 hr, a 1: 2 adduct IIIa of Ia and IIa was obtained in 91% yield. Even when Ia was employed in excess, the 1: 1 adduct was not formed and the 1: 2 adduct IIIa was again obtained albeit in low yield.

The IR spectrum of IIIa showed bands ascribable to ν_{NH} and $\nu_{C=O}$ at 3390 and 1635 cm^{-1} respectively. The NMR spectrum in deuteriochloroform ($CDCl_3$) displayed signals at δ 2.0 (3H, CH_3), 4.08 (2H, CH_2), 11.58 and 11.96 ppm (each 1H, NH), besides piperidyl and aromatic protons. The 1: 2 adduct was thus confirmed to be 3,5-di(phenylcarbamoyl)-4-(1-piperidyl)-3-penten-2-one (IIIa).



I	II	III
a: n=1	a: R=H	a: n=1, R=H
b: n=0	b: R=Cl	b: n=0, R=H
	c: R=CH_3	c: n=0, R=Cl
		d: n=0, R=CH_3

Scheme 1.

Similarly, the reaction of 4-(1-pyrrolidinyl)-3-penten-2-one (Ib) with phenyl (IIa), *p*-chlorophenyl (IIb), and *p*-tolyl isocyanate (IIc) in benzene gave the corresponding 1: 2 adducts IIIb—IIId, respectively (Scheme 1).[12] The NMR spectra showed that the adducts III exist as a mixture of two tautomers, 3-penten-2-one and 4-penten-2-one.

Hydrolysis of both IIIa and IIIb with 18% hydrochloric acid gave IV. In view of the spectral data and identification with an authentic sample prepared from dimethyl β-ketoglutarate and aniline, IV was confirmed to be 1,3-di(phenylcarbamoyl)acetone; a singlet assignable to an olefinic proton at δ 5.88 ppm in its NMR spectrum suggests that IV exists in its

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[1] Part I of this series: O. Tsuge, M. Tashiro, and Y. Nishihara, *Nippon Kagaku Zasshi*, **92**, 72 (1971).

[2] To whom inquiries should be directed.

[3] M. Perelman and S. A. Mizsak, *J. Amer. Chem. Soc.*, **84**, 4988 (1962).

[4] G. Opitz and J. Koch, *Angew. Chem.*, **75**, 167 (1963).

[5] A. K. Bose and G. Mina, *J. Org. Chem.*, **30**, 812 (1965).

[6] S. Hünig, K. Hübnev, and E. Benzig, *Chem. Ber.*, **95**, 926 (1962).

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[8] C. A. Grob and H. J. Wilkens, *Helv. Chem. Acta*, **50**, 725 (1967).

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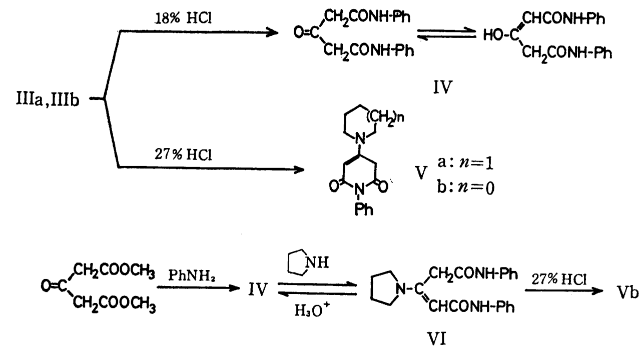
[10] G. H. Alt and A. J. Speziale, *J. Org. Chem.*, **29**, 794 (1964); *ibid.*, **30**, 1407 (1965).

[11] M. Yoshimoto, T. Hiraoka, and Y. Kishida, *Chem. Pharm. Bull.* (Tokyo), **18**, 2469 (1970).

[12] The product isolated from Ib and IIa was, however, a complex of IIIb and benzene, which on treatment with ethanol afforded pure IIIb.



Scheme 2.

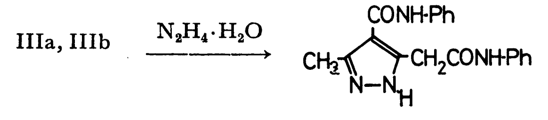
enol form in $CDCl_3$.

Treatment of IIIb with 27% hydrochloric acid afforded a new product Vb as reddish brown plates, whose molecular formula ($C_{15}H_{16}N_2O_2$) corresponded to that of a compound derived from IIIb by the elimination of both an acetyl and an anilino group. The IR spectrum of Vb displayed two crabonyl bands at 1645 and 1694 cm^{-1}. The NMR spectrum exhibited singlets at δ 3.60 (2H, $\mathbf{CH_2}$) and 5.0 ppm (1H, =**CH**), besides pyrrolidinyl (8H) and phenyl protons (5H). These spectral data suggested V to be 1-phenyl-4-(1-pyrrolidinyl)-1,2,6-trihydropyridine-2,6(5H)-dione; Vb was indeed identical with an authentic sample prepared by the treatment of dianilide VI with 27% hydrochloric acid (Scheme 2).

A similar treatment of IIIa gave a mixture of IV and Va, identified by its spectral properties. However, Va could not be isolated in pure form.

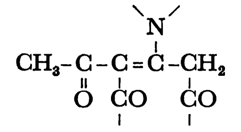
Although the exact pathway for the hydrolysis of III is not clear, it can be considered to arise from the initial formation of dianilide VI, followed by hydrolysis or deanilination depending on the strength of hydrochloric acid.

The reaction of IIIa and IIIb with hydrazine hydrate afforded 3(5)-phenylcarbamoylmethyl-4-phenylcarbamoyl-5(3)-methylpyrazole (VII), whose structure was confirmed by its spectral data as well as by its elemental analysis.



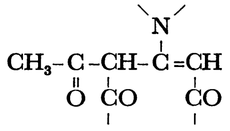
VII

Tautomerism of III. The NMR spectrum of IIIa indicated that it exists as the 3-penten-2-one of type A in $CDCl_3$. However, it has been clarified that all adducts of type III exist in general as a mixture of the 3-penten-2-one (type A) and 4-penten-2-one (type B) in solution, *e.g.*,



$$CH_3\text{-}\underset{O}{\overset{\|}{C}}\text{-}\underset{\underset{|}{CO}}{C}=\overset{\overset{\diagdown N \diagup}{|}}{C}\text{-}\underset{\underset{|}{CO}}{CH_2}$$

A



$$CH_3\text{-}\underset{O}{\overset{\|}{C}}\text{-}\underset{\underset{|}{CO}}{CH}\text{-}\overset{\overset{\diagdown N \diagup}{|}}{C}=\underset{\underset{|}{CO}}{CH}$$

B

As illustrated in Fig. 1 the NMR spectrum of IIIb in pyridine-d_5 can be understood as that of a 1:1

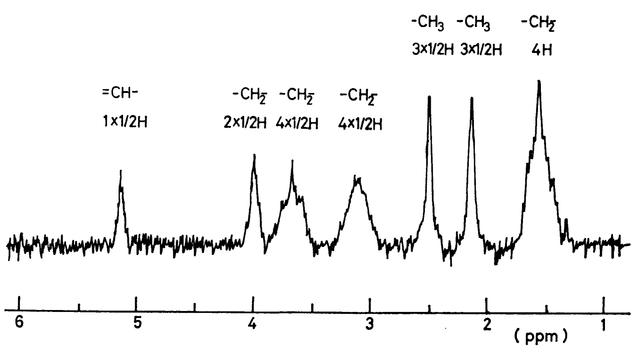


Fig. 1. NMR spectrum of IIIb in pyridine-d_5

mixture of the corresponding A and B of IIIb.

The ratios of A to B in all III in solutions were similarly calculated; the results are summarized in Table 1.

Table 1. Ratio of A to B in III

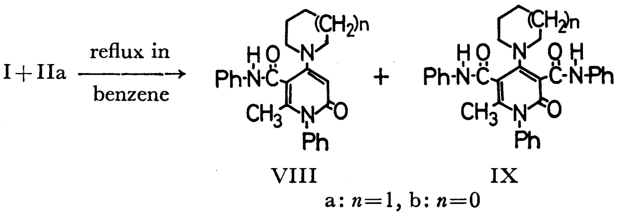
III	A:B	Solvent
IIIa	1:0	$CDCl_3$
IIIa	2:3	DMSO-d_6
IIIa	1:1	Pyridine-d_5
IIIb	3:2	$CDCl_3$
IIIb	1:1	Pyridine-d_5
IIIb	1:2	DMSO-d_6
IIIc	1:2	$CDCl_3$
IIId	3:2	$CDCl_3$

On heating, IIIa and IIIb (but not IIIc) easily underwent elimination of water to give VIIIa and VIIIb.

Reaction under Reflux in Benzene. When Ia was treated with two equivalents of isocyanate IIa in refluxing benzene for 5 hr, two products VIIIa and IXa were obtained, but not IIIa.

The molecular formula of the major product VIIIa corresponded to that of the compound derived from a 1:2 adduct with loss of water. The IR spectrum of VIIIa exhibited bands assignable to ν_{NH} and $\nu_{C=O}$ at 3280 and 1645, 1663 cm^{-1}, and the NMR spectrum in $CDCl_3$ displayed singlets at δ 2.13 (3H, $\mathbf{CH_3}$), 5.97 (1H, =**CH**), and 8.64 ppm (1H, **NH**), besides piperidyl (10H) and aromatic protons (10H). VIIIa was thus deduced to be 6-methyl-1-phenyl-5-phenylcarbamoyl-4-(1-piperidyl)pyrid-2-one. The mass spectrum supported the proposed structure for VIIIa.

The minor product IXa corresponded to a compound derived from a 1:3 adduct of Ia and IIa with loss of water. The IR spectrum of IXa was very similar to that of VIIIa showing bands ascribable to ν_{NH} and $\nu_{C=O}$ at 3300 and 1630, 1650 cm^{-1}. Its NMR spectrum in deuteriodimethylsulfoxide (DMSO-d_6) dis-



VIII IX

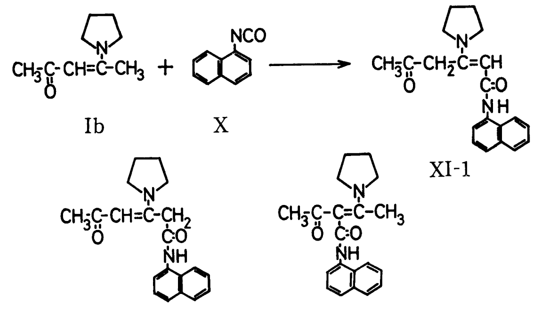
a: n=1, b: n=0

played singlets at δ 1.95 (3H, **CH**$_3$), 10.28 and 10.56 ppm (each 1H, **NH**), together with piperidyl (10H) and aromatic protons (15H). The results leave little doubt that IXa is 3,5-di(phenylcarbamoyl)-6-methyl-1-phenyl-4-(1-piperidyl)pyrid-2-one.

Under similar conditions, the reaction of Ib with IIa in refluxing benzene afforded 3,5-di(phenylcarbamoyl)-4-(1-pyrrolidinyl)pyrid-2-one IXb and a 2: 1 complex of 5-phenylcarbamoyl-4-(1-pyrrolidinyl)pyrid-2-one VIIIb and *s*-diphenylurea. On heating with hydrochloric acid–acetic acid mixture, the 2: 1 complex decomposed into its components VIIIb and *s*-diphenylurea.

As mentioned above, the structure of VIII corresponds to that of the compound obtainable from 1: 2 adduct III with concurrent dehydration. When an ethanol solution of IIIa or IIIb was refluxed for 5 hr, the corresponding product VIIIa or VIIIb was obtained.[13] The formation of VIII under reflux in benzene can therefore be considered to proceed by the initial formation of 1: 2 adduct III, followed by dehydration. On the other hand, VIII did not react with phenyl isocyanate (IIa); the pathway for the formation of IX has not yet been elucidated.

The reaction of enamino ketone Ib with 1-naphthyl isocyanate (X) at room temperature did not occur, but under reflux in benzene a 1: 1 adduct XI was obtained in a small amount, together with *s*-di(1-naphthyl)urea and 1-(1-naphthyl)-2-(1-pyrrolidinyl)-urea; neither 1:2 adduct nor the product resulting from loss of water was formed.



Scheme 3.

The IR spectrum of XI showed bands assignable to ν_{NH} and $\nu_{C=O}$ at 3000 and 1690 cm^{-1}. The NMR spectrum exhibited singlets at δ 2.21 (3H, **CH**$_3$), 4.20 (2H, **CH**$_2$), 5.15 (1H, =**CH**), and 10.96 ppm (1H, **NH**) besides pyrrolidinyl (8H) and aromatic protons (7H). Thus, it seems that XI is 4-(1-pyrrolidinyl)-5-(1-naphthylcarbamoyl)pent-4-en-2-one (XI-1) rather than XI-2 or XI-3 (Scheme 3).

Experimental

All melting points are uncorrected. The IR spectra were measured as KBr pellets on a Nippon Bunko IR-S spectrophotometer; the NMR spectra were determined at 60 MHz on a Hitachi R-20 NMR spectrometer with TMS as internal reference. The mass spectra were obtained on a Hitachi RMS-4 mass spectrometer with a direct inlet and an ionization energy of 70 eV. The elemental analyses were performed by Miss M. Akita.

Materials. *4-(1-Piperidyl)-3-penten-2-one (Ia)*: A solution of 5.0 g (0.05 mol) of acetylacetone and 8.5 g (0.1 mol) of piperidine in 700 ml of dry benzene was refluxed until a theoretical amount of water was distilled out (about 15 hr). The reaction mixture was concentrated to leave a residue. The distillation of the residue gave yellow viscous liquid (bp 122—123°C/7 mmHg), which on standing solidified. Recrystallization from petroleum ether (bp 30—45°C) afforded 6.5 g (78%) of Ia, mp 47—47.5°C (decomp.), colorless prisms.

Found: C, 71.76; H, 10.55; N, 8.43%. Calcd for $C_{10}H_{17}NO$: C, 71.86; H, 10.42; N, 8.38%.

4-(1-Pyrrolidinyl)-3-penten-2-one (Ib) was prepared according to the published procedure.[14] Mp 114—115°C (decomp.), (lit,[14] mp 115—116°C). Phenyl (IIa), *p*-chlorophenyl (IIb), *p*-tolyl (IIc) and 1-naphthyl isocyanate (X) were obtained commercially.

Reaction of 4-(1-Piperidyl)-3-penten-2-one (Ia) with Phenyl Isocyanate (IIa). *i) At Room Temperature*: A solution of 1.67 g (0.01 mol) of Ia and 2.38 g (0.02 mol) of IIa in 50 ml of benzene was stirred at room temperature for 5 hr, during which time crystals precipitated. Filtration gave crystals, which on recrystallization from ethanol below 50°C afforded 3.7 g (91%) of 3,5-di(phenylcarbamoyl)-4-(1-piperidyl)-3-penten-2-one (IIIa), mp 168.5—169°C (decomp.), as colorless needles.

Found: C, 71.17; H, 6.83; N, 10.42%. Calcd for $C_{24}H_{27}N_3O_3$: C, 71.09; H, 6.71; N, 10.36%.

NMR (in $CDCl_3$) δ ppm: 1.70 (6H, multiplet, **CH**$_2$), 2.0 (3H, singlet, **CH**$_3$), 3.87 (4H, multiplet, **CH**$_2$), 4.08 (2H, singlet, **CH**$_2$), 7.0—8.0 (10H, multiplet, aromatic protons), 11.58, 11.96 (each 1H, singlet, **NH**).

Similarly, the reaction of 4-(1-pyrrolidinyl)-3-pentene-2-one (Ib) with IIa, *p*-chlorophenyl (IIb) and *p*-tolyl isocyanate (IIc) gave the corresponding 1: 2 adducts IIIb, IIIc, and IIId respectively. However, the product isolated from the reaction of Ib with IIa was a 2: 1 complex of IIIb and benzene, which on treatment with ethanol afforded pure IIIb.

The 2: 1 complex of IIIb and benzene: mp 131—132°C (decomp.), colorless needles.

Found: C, 72.91; H, 6.35; N, 9.68%. Calcd for $(C_{23}H_{25}N_3O_3)_2\cdot C_6H_6$: C, 72.56; H, 6.51; N, 9.79%.

IR cm^{-1}: ν_{NH} 3280, 3230; $\nu_{C=O}$ 1706, 1640. Mass spectrum *m/e*: 373 (IIIb$^+$−H_2O), 78 ($C_6H_6^+$).

Recrystallization of the complex from ethanol below 50°C gave 1: 2 adduct IIIb, mp 165—166°C (decomp.), as colorless needles. Yield, 65%.

Found: C, 70.29; H, 6.32; N, 10.72%. Calcd for $C_{23}H_{25}N_3O_3$: C, 70.57; H, 6.44; N, 10.74%.

IR cm^{-1}: ν_{NH} 3390, 3345; $\nu_{C=O}$ 1650. NMR (in $CDCl_3$) δ ppm: 1.89 (4H, multiplet, **CH**$_2$), 1.95 (3×2/5H, singlet, **CH**$_3$), 2.22 (3×3/5H, singlet, **CH**$_3$), 3.40 (4×2/5H, multiplet, **CH**$_2$), 3.57 (4×3/5H, multiplet, **CH**$_2$), 3.98 (2×3/5H, singlet, **CH**$_2$), 4.85 (1×2/5H, broad, =**CH**), 6.8—7.8 (10H, multiplet, aromatic protons), 9.80 (1H, broad, **NH**), 10.56 (1H, singlet, **NH**).

1: 2 Adduct IIIc: mp 162—163°C, colorless needles. Yield, 40%.

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[13] When a solution of IIIa or IIIb in ethanol was gently heated below 50°C for a long time, their isomers IIIa′, mp 257—260°C (decomp.), and IIIb′, mp 179—180°C (decomp.), respectively, were formed. However, their structures have not yet been elucidated.

[14] N. J. Leonard and J. A. Adamcik, *J. Amer. Chem. Soc.*, **81**, 595 (1959).

Found: C, 60.07; H, 5.13; N, 9.06%. Calcd for $C_{23}H_{23}N_3O_3Cl_2$: C, 60.00; H, 5.00; N, 9.13%.

IR cm^{-1}: ν_{NH} 3320; $\nu_{C=O}$ 1650, 1630. NMR (in $CDCl_3$) δ ppm: 1.90 (4H, multiplet, **CH_2**), 2.0 ($3\times 2/3$H, singlet, **CH_3**), 2.18 ($3\times 1/3$H, singlet, **CH_3**), 3.39 ($4\times 1/3$H, multiplet, **CH_2**), 3.73 ($4\times 1/3$H, multiplet, **CH_2**), 3.95 ($2\times 1/3$H, singlet, **CH_2**), 5.41 ($1\times 2/3$H, singlet, **=CH**), 6.9—7.7 (8H, multiplet, aromatic protons), 9.8 (1H, singlet, **NH**), 10.25 ($1\times 1/3$H, singlet, **NH**), 10.70 ($1\times 2/3$H, singlet, **NH**). Mass spectrum *m/e*: 463, 461, 459 (M^+).

1: 2 Adduct IIId: mp 138—140°C, colorless crystals. Yield, 49%.

Found: 72.06; H, 7.10; N, 9.72%. Calcd for $C_{25}H_{29}N_3O_3$: C, 71.57; H, 6.97; N, 10.02%.

IR cm^{-1}: ν_{NH} 3245, 3180; $\nu_{C=O}$ 1695, 1630. NMR (in $CDCl_3$) δ ppm: 1.90 (4H, multiplet, **CH_2**), 1.99 ($3\times 2/5$H, singlet, **CH_3**), 2.24 ($3\times 3/5$H, singlet, **CH_3**), 2.30 (6H, singlet, **CH_3**), 3.40 ($4\times 2/5$H, multiplet, **CH_2**), 3.68 ($4\times 3/5$H, multiplet, **CH_2**), 3.96 ($2\times 3/5$H, singlet, **CH_2**), 5.50 ($1\times 2/5$H, singlet, **=CH**), 6.9—7.8 (8H, multiplet, aromatic protons), 9.37 ($1\times 2/5$H, broad, **NH**), 9.6 (1H, broad, **NH**), 10.52 ($1\times 3/5$H, broad, **NH**).

ii) Under Reflux in Benzene: A solution of 1.67 g (0.01 mol) of Ia and 2.38 g (0.02 mol) of IIa in 50 ml of benzene was refluxed for 5 hr. After cooling, filtration gave crystals, which on recrystallization from ethanol afforded 0.97 g (25%) of 6-methyl-1-phenyl-5-phenylcarbamoyl-4-(1-piperidyl)-pyrid-2-one (VIIIa), mp 266—268°C (decomp.), as colorless needles.

Found: C, 74.22; H, 6.78; N, 10.63%. Calcd for $C_{24}H_{25}N_3O_2$: C, 74.39; H, 6.50; N, 10.85%. Mass spectrum *m/e*: 387 (M^+).

The benzene filtrate was concentrated *in vacuo* to leave a residue. The residue was washed with ethanol to give crystals, which on recrystallization from benzene afforded 0.2 g (6%) of 3,5-di(phenylcarbamoyl)-6-methyl-1-phenyl-4-(1-piperidyl)-pyrid-2-one (IXa), mp 280—281°C, as colorless needles.

Found: C, 73.89; H, 6.00; N, 10.75%. Calcd for $C_{31}H_{30}N_4O_3$: C, 73.49; H, 5.97; N, 11.06%.

Similarly, the reaction of 1.53 g (0.01 mol) of Ib with 2.38 g (0.02 mol) of IIa gave 1.60 g (43%) of a 2: 1 complex of VIIIb and *s*-diphenylurea, mp 228°C (decomp.), and 0.27 g of IXb, mp 272°C (decomp.), as both colorless prisms.

The complex; Found: C, 73.89; H, 5.72; N, 11.88%. Calcd for $(C_{23}H_{23}N_3O_2)_2\cdot C_{13}H_{12}N_2O$: C, 73.83; H, 6.04; N, 11.90%.

IR cm^{-1}: ν_{NH} 3290; $\nu_{C=O}$ 1700, 1674, 1636. NMR (in DMSO-d_6) δ ppm: 1.85 (4H, multiplet, **CH_2**), 1.88 (3H, singlet, **CH_3**), 3.40 (4H, multiplet, **CH_2**), 5.42 (1H, singlet, **=CH**), 7.0—8.0 (15H, multiplet, aromatic protons), 8.75, 10.75 (each 1H, singlet, **NH**). Mass spectrum *m/e*: 273 ($VIIIb^+$).

Compound IXb; Found: C, 73.34; H, 6.03; N, 11.19%. Calcd for $C_{30}H_{28}N_4O_3$: C, 73.15; H, 5.73; N, 11.38%.

IR cm^{-1}: ν_{NH} 3320; $\nu_{C=O}$ 1656, 1634. NMR (in DMSO-d_6) δ ppm: 1.75 (4H, multiplet, **CH_2**), 1.88 (3H, singlet, **CH_3**), 3.50 (4H, multiplet, **CH_2**), 6.9—7.8 (15H, multiplet, aromatic protons), 10.62, 10.82 (each 1H, singlet, **NH**). Mass spectrum *m/e*: 492 (M^+).

A solution of 1.0 g of the complex in 50 ml of concentrated hydrochloric acid–acetic acid mixture (1:1 vol/vol) was refluxed for 20 hr. After cooling, filtration gave 0.12 g of *s*-diphenylurea. The filtrate was concentrated *in vacuo* to leave a residue, which on several recrystallizations from ethanol afforded 0.25 g of pure VIIIb, mp 248—250°C (decomp.), as colorless prisms.

Found: C, 73.63; H, 6.50; N, 11.03%. Calcd for $C_{23}H_{23}N_3O_2$: C, 73.97; H, 6.21; N, 11.25%.

IR cm^{-1}: ν_{NH} 3265; $\nu_{C=O}$ 1660, 1645. NMR (in $CDCl_3$) δ ppm: 1.91 (4H, multiplet, **CH_2**), 2.08 (3H, singlet, **CH_3**), 3.47 (4H, multiplet, **CH_2**), 5.43 (1H, singlet, **=CH**), 7.0—7.7 (10H, multiplet, aromatic protons), 9.60 (1H, singlet, **NH**). Mass spectrum *m/e*: 273 (M^+).

Hydrolysis of 1: 2 Adduct III. A solution of 1.0 g of IIIa in 10 ml of 18% hydrochloric acid was stirred at room temperature for 6 hr. Water was added to the reaction mixture and then the precipitated solid was filtered. Recrystallization from ethanol–petroleum ether mixture afforded 0.2 g (27%) of 1,3-di(phenylcarbamoyl)acetone (IV), mp 151—152°C (lit,[15] mp 155°C), as colorless plates.

Found: C, 68.98; H, 5.30; N, 9.30%. Calcd for $C_{17}H_{16}N_2O_3$: C, 68.90; H, 5.44; N, 9.46%.

IR cm^{-1}: ν_{NH} 3270; $\nu_{C=O}$ 1720, 1650. NMR (in pyridine-d_5) δ ppm: 3.8 (4H, broad, **CH_2**), 6.8—7.9 (19H, multiplet, aromatic protons), 10.8 (2H, broad, **NH**). Mass spectrum *m/e*: 296 (M^+).

Similarly, hydrolysis of IIIb gave IV in 30% yield. Compound IV was identical with an authentic sample prepared from dimethyl β-ketoglutarate and aniline.

1-Phenyl-4-(1-pyrrolidinyl)-1,2,6-trihydropyridine-2,6(5H)-dione (Vb). i) A solution of 1.0 g of IIIb in 15 ml of 27% hydrochloric acid was stirred at room temperature for 20 hr. The reaction mixture was poured into water and the precipitated solid was filtered. Recrystallization from ethanol–petroleum ether afforded 0.2 g (30%) of Vb, mp 214—216°C (decomp.), as reddish brown plates.

Found: C, 70.08; H, 6.26; N, 10.88%. Calcd for $C_{15}H_{16}N_2O_2$: C, 70.29; H, 6.29; N, 10.93%. Mass spectrum *m/e*: 256 (M^+).

ii) A solution of 5.92 g of IV and 10 ml of pyrrolidine in 50 ml of benzene was stirred at room temperature for 15 hr and then 30 ml of petroleum ether was added to the reaction mixture. Filtration afforded 6.50 g (93%) of dianilide VI, mp 174—175°C, as colorless needles.

Found: C, 72.29; H, 6.73; N, 12.15%. Calcd for $C_{21}H_{23}N_3O_2$: C, 72.18; H, 6.63; N, 12.03%.

IR cm^{-1}: ν_{NH} 3310; $\nu_{C=O}$ 1675. NMR (in $CDCl_3$) δ ppm: 1.79 (4H, multiplet, **CH_2**), 3.38 (4H, multiplet, **CH_2**), 4.54 (1H, singlet, **=CH**), 6.8—7.7 (11H, multiplet, aromatic protons and NH), 11.11 (1H, singlet, **NH**). Mass spectrum *m/e*: 349 (M^+).

Treatment of 1.0 g of VI with 10 ml of 27% hydrochloric acid gave 0.15 g of Vb. Hydrolysis of VI with 18% hydrochloric acid also afforded IV quantitatively.

Reaction of 1: 2 Adduct IIIa with Hydrazine Hydrate. A solution of 1.0 g of IIIa and 5 ml of hydrazine hydrate in 20 ml of ethanol was stirred at room temperature for 5 hr. The reaction mixture was concentrated *in vacuo* to leave a residue, which on recrystallization from ethanol afforded 0.25 g (31%) of pyrazole derivative VII, mp 239—240°C, as colorless needles.

Found: C, 68.09; H, 5.27; N, 16.64%. Calcd for $C_{19}H_{18}N_4O_2$: C, 68.24; H, 5.42; N, 16.76%.

IR cm^{-1}: ν_{NH} 3240; $\nu_{C=O}$ 1650, 1630. NMR (in $CDCl_3$) δ ppm: 2.50 (3H, singlet, **CH_3**), 3.95 (2H, singlet, **CH_2**), 7.0—8.0 (11H, multiplet, aromatic protons and NH), 10.55, 11.07 (each 1H, singlet, **NH**). Mass spectrum *m/e*: 334 (M^+).

Reaction of Enamino Ketone Ib with 1-Naphthyl Isocyanate (X). A solution of 1.53 g (0.01 mol) of Ib and 1.69 g (0.01 mol) of X in 50 ml of benzene was refluxed for 16 hr. After cooling, filtration gave 0.34 g of a mixture of *s*-di(1-naphthyl)urea and 1-(1-naphthyl)-2-(1-pyrrolidinyl)urea. Fractional recrystal-

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[15] E. Besthorn and E. Garben, *Ber.*, **33**, 3443 (1900).

lization from ethanol afforded pure *s*-di(1-naphthyl)urea, mp 268—270°C (decomp.) (lit,[16] mp 270—314°C (decomp.)), and 1-(1-naphthyl)-2-(1-pyrrolidinyl)urea, mp 134—135°C. Both ureas were identical with authentic samples prepared from 1-naphthyl isocyanate and 1-naphthylamine or pyrrolidine, respectively.

The filtrate was concentrated *in vacuo* to leave a residue, which was washed with petroleum ether. Recrystallization of the insoluble solid from ethanol–petroleum ether afforded 0.32 g of 1: 1 adduct XI, mp 165—166°C (decomp.), as colorless needles.

Found: C, 74.39; H, 6.60; N, 8.60%. Calcd for $C_{20}H_{22}N_2O_2$: C, 74.51; H, 6.88; N, 8.69%. Mass spectrum *m/e*: 322 (M^+).

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16) J. W. Boehmer, *Rec. Trav. Chim. Pays-Bas,* **55**, 379 (1936).