Studies of Enamines. VIII.[1] Reactions of Enamino Ketones with Benzoyl and Thiobenzoyl Isocyanates

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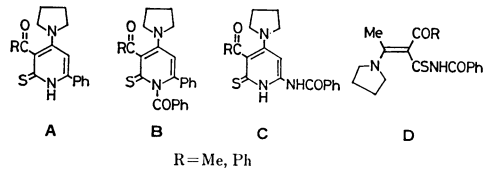
The reaction of enamino ketone **1**, derived from acetylacetone, with benzoyl isocyanate (**4**) gave the isomeric benzoylcarbamoyl derivatives **6** and **9**, and/or 2-pyridone **7**, depending upon the reaction conditions. Similarly, enamino ketone **2**, derived from benzoylacetone, reacted with **4** to afford the isomeric benzoylcarbamoyl compounds **12**, **13**, and/or 2-pyrone **14**. It has been found that the carbamoyl compound **12** was thermally converted into **13** and **14**. Enamino ketones **1** and **2** reacted with thiobenzoyl isocyanate (**5**) at room temperature to yield the 2-pyridones **7** and **15**, respectively. On the other hand, enamino ketones **3**, derived from benzoylacetaldehyde and secondary amines, reacted with **4** to give the corresponding 2-benzoylcarbamoyl-2-penten-2-one compound **18**, while in the reaction with **5**, **3** gave the 1,3-thiazin-4-one **19** and/or (4+2) cycloaddut **20**.

In a previous paper,[1] we reported that enamino ketones, 4-(1-pyrrolidinyl)-3-penten-2-one (**1**) and 1-phenyl-3-(1-pyrrolidinyl)-2-buten-1-one (**2**), react with benzoyl isothiocyanate to yield 2-thiopyridone derivatives, **A**—**C**, and/or 3-benzoylthiocarbamoyl-3-penten-2-one compound **D** (R=Me), depending upon the nature of enamino ketones and the reaction conditions. Although a few reports are available on the reaction of simple enamines with acyl and thioacyl isocyanates,[2-4] the reaction of enamino ketones with these isocyanates has not been investigated.

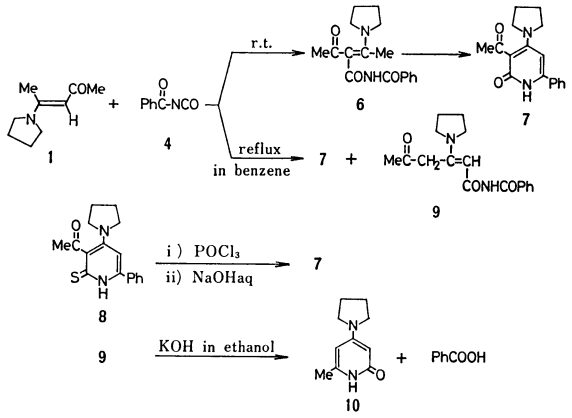


For a comparison with the reactions of enamino ketones with aryl isocyanates,[5] and with benzoyl isothiocyanate,[1] it seemed of interest to investigate the reaction of enamino ketones, **1** and **2**, with acyl and thioacyl isocyanates. It might be expected that enamino ketones, **3**, derived from benzoylacetaldehyde which were inactive toward phenyl isocyanate, would be able to react with acyl isocyanates, since acyl isocyanates are one of the most reactive systems among isocyanates. This paper deals with the reactions of enamino ketones, **1**—**3**, with benzoyl (**4**) and thiobenzoyl isocyanates (**5**).

Results and Discussion

Reaction of Enamino Ketone 1. When a solution of equimolar quantities of **1** and benzoyl isocyanate (**4**) in benzene was stirred at room temperature for 6 h, a product **7**, mp 264—266 °C (decomp), was obtained as colorless prisms in a 35% yield, together with 1,2-dibenzoylurea and benzamide.

On the basis of the following evidence, compound **7** was assigned to be 3-acetyl-6-phenyl-4-(1-pyrrolidinyl)-2-pyridone whose structure corresponds to that of a compound arising from 3-benzoylcarbamoyl-4-(1-pyrrolidinyl)-3-penten-2-one (**6**) by dehydration. The molecular formula of **7** agrees with that of the assigned structure, the IR spectrum showing bands at 2800—3000 (NH) and 1645 cm^{-1} (C=O), respectively. The NMR spectrum in $CDCl_3$ displays signals at δ 2.62 (3H, s, C**H**$_3$), 6.10 (1H, s, =C**H**), and 12.27 ppm (1H, br, N**H**), besides pyrrolidinyl and aromatic protons. **7** is identical with a sample prepared by the reaction of 3-acetyl-6-phenyl-4-(1-pyrrolidinyl)-2-thiopyridone (**8**)[1] with phosphoryl chloride, and the subsequent hydrolysis (Scheme 1).



Scheme 1.

Although attempts to isolate the 1 : 1 adduct **6** were unsuccessful, it was confirmed by NMR spectroscopic study that the 1 : 1 adduct **6** is initially formed in the reaction of **1** with **4**. The NMR of a solution of equimolar quantities of **1** and **4** in $CDCl_3$ was measured at room temperature. The spectrum changed with time, and after about 30 min it showed only signals ascribable to the protons of **6**. That is, signals appeared at δ 1.95, 3.79 (each 4H, m, C**H**$_2$), 2.01, 2.51 (each 3H, s, C**H**$_3$), 7.2—8.2 (5H, m, aromatic protons), and 13.9 ppm (1H, br, N**H**). After 2 h, a singlet ascribable to a ring proton of **7** showed up at δ 6.10 ppm.

On the other hand, **1** reacted with **4** in refluxing benzene to afford **7** and 5-benzoylcarbamoyl-4-(1-pyrrolidinyl)-4-penten-2-one (**9**), mp 152—153 °C, in 12 and 15% yields respectively, together with 1,2-dibenzoylurea. The structure of **9** was assigned from the result of microanalysis and of spectral data. The

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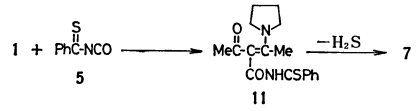
IR spectrum exhibited bands at 3240 (NH), 1690, 1720 (C=O), and 1635 cm^{-1} (C=C), and the NMR spectrum in $CDCl_3$ showed signals at δ 2.12 (3H, s, CH_3), 4.02 (2H, s, CH_2), 5.01 (1H, s, =CH), and 12.7 ppm (1H, br, NH), besides pyrrolidinyl and aromatic protons. Treatment of **9** with an ethanolic potassium hydroxide solution at room temperature for 5 h gave benzoic acid and 6-methyl-4-(1-pyrrolidinyl)-2-pyridone (**10**), mp 273—275 °C (decomp), in 37 and 76% yields, respectively (Scheme 1). In contrast to the 1 : 1 adduct **6**, however, the 1 : 1 adduct **9** remarkably resisted dehydration.

The reaction of **1** with thiobenzoyl isocyanate (**5**) at room temperature proceeded in the same manner as that with isocyanate **4**. After **1** was allowed to react with **5** at room temperature for 1 h, the reaction mixture was chromatographed on alumina to give pyridone **7** in only 3% yield, together with **1**. However, an initial product in the reaction was found to be 3-thiobenzoylcarbamoyl-4-(1-pyrrolidinyl)-3-penten-2-one (**11**), which was partially converted into **7** with time, by NMR spectroscopic study in nitrobenzene-d_5 (see Experimental).

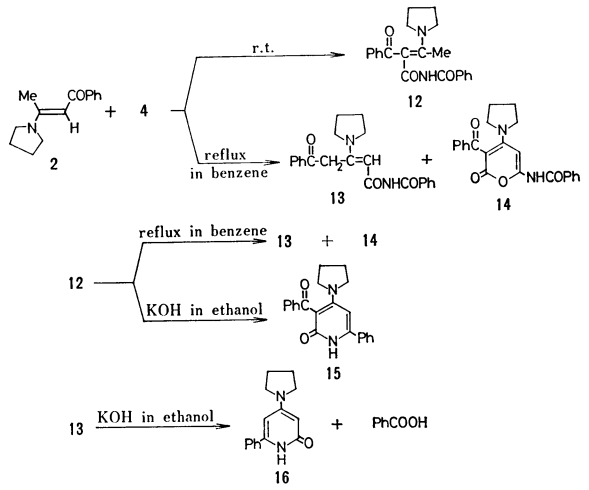


Reaction of Enamino Ketone **2**. Enamino ketone **2** reacted with an equimolar quantity of the isocyanate **4** in benzene at room temperature for 5 h to give 2-benzoylcarbamoyl-1-phenyl-3-(1-pyrrolidinyl)-2-buten-1-one (**12**), mp 133—134 °C (decomp), in a good yield. Since the 1 : 1 adduct **12** is liable to thermally decompose, **12** was recrystallized from a mixture of ethanol and petroleum ether (bp 40—60 °C) below 50 °C, and its structure was deduced from the spectral data.

On the other hand, the reaction of **2** with **4** in refluxing benzene afforded two compounds, **13** (mp 141—142 °C), and **14** (mp 187—188 °C), in 15 and 17.5% yields respectively, together with 1,2-dibenzoylurea. From the spectral data, compound **13** was assigned to 4-benzoylcarbamoyl-1-phenyl-3-(1-pyrrolidinyl)-3-buten-1-one.

The molecular formula of **14** agreed with that of a compound derived from an 1 : 2 adduct of **2** and **4** with the elimination of benzamide. The IR spectrum of **14** showed bands at 3240 (NH), 1650, 1670, and 1725 cm^{-1} (C=O), and the NMR spectrum in $CDCl_3$ displayed signals at δ 6.65 (1H, s, =CH) and 12.33 ppm (1H, br, NH), besides pyrrolidinyl and aromatic protons. Thus, compound **14** was deduced to be 3-benzoyl-6-benzamido-4-(1-pyrrolidinyl)-2-pyrone. Further support for this assignment of **14** was provided by its chemical conversions.

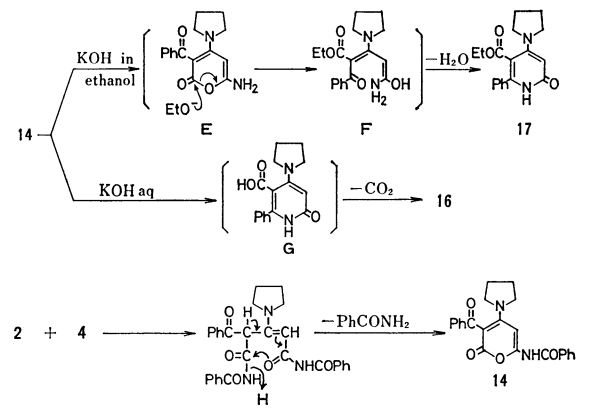
When a benzene solution of the 1 : 1 adduct **12** was refluxed for 1 h, the 1 : 1 adduct **13** and pyrone **14** were obtained in 17 and 15% yields, respectively, together with 1,2-dibenzoylurea and benzamide. This indicates that the 1 : 1 adduct **12** thermally dissociates into the starting materials **2** and **4**, giving **13** and **14**. On treatment with an ethanolic potassium hydroxide



Scheme 2.

solution, the 1 : 1 adduct **12** was converted into 3-benzoyl-6-phenyl-4-(1-pyrrolidinyl)-2-pyridone (**15**) in a 42% yield. On the other hand, the same treatment of the 1 : 1 adduct **13** gave a 56% yield of 6-phenyl-4-(1-pyrrolidinyl)-2-pyridone (**16**) (Scheme 2).

In order to obtain further information on the structure of the pyrone **14**, its chemical conversions were attempted. On treatment with an ethanolic potassium hydroxide solution at room temperature, **14** was converted into 5-ethoxycarbonyl-6-phenyl-4-(1-pyrrolidinyl)-2-pyridone (**17**), mp 236—238 °C, in an 87% yield. The structure of **17** was assigned on the basis of the following evidence. The IR spectrum of **17** showed bands at 2800—3080 (NH), 1730 (C=O), and 1600—1630 cm^{-1} (C=O and C=C). The NMR spectrum in $CDCl_3$ displayed signals at δ 1.33 (3H, t, CH_2CH_3), 4.33 (2H, q, CH_2Me), 6.02 (1H, s, =CH), and 11.8—12.4 ppm (1H, br, NH), besides pyrrolidinyl and aromatic protons. The mass spectrum showed the parent peak (M^+) at *m/e* 312, together with major peaks at *m/e* (M^+—Et), 267 (M^+—OEt), and 239 (267^+—CO, base peak). The pathway for the formation of **17** from **14** could be interpreted as depicted in Scheme 3. 6-Amino-3-benzoyl-4-(1-pyrrolidinyl)-2-pyrone (**E**) would be initially formed by hydrolytic cleavage of benzamido group of **14**. This would be

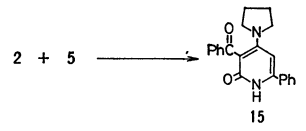


Scheme 3.

followed by attack of ethoxide ion to yield an open chain intermediate **F**, and the concurrent dehydration would give the final product **17**. On the other hand, **14** afforded the pyridone **16** in an 85% yield when treated with an aqueous potassium hydroxide solution. The formation of **16** from **14** could be reasonably interpreted by decarboxylation of 2-pyridone-5-carboxylic acid derivative **G** produced in a similar way to that for **17**.

Enamino ketone **1** reacts with aryl isocyanates to yield 1 : 2 adducts, 3,5-bis(arylcarbamoyl)-4-(1-pyrrolidinyl)-3-penten-2-ones.[5] Thus, the pathway for the formation of **14** can be viewed as depicted in Scheme 3. That is, enamino ketone **2** would react with two moles of **4** to form 1-phenyl-2,4-bis(phenylcarbamoyl)-3-(1-pyrrolidinyl)-3-buten-1-one(**H**).[6] A nucleophilic attack of the oxygen atom of 4-benzoylcarbamoyl group to the carbon atom of 2-benzoylcarbamoyl group, and the concurrent elimination of benzamide from **H** would give the pyrone **14**.

On the other hand, **2** reacted with thiobenzoyl isocyanate (**5**) in xylene at room temperature for 2 h gave 3-benzoyl-6-phenyl-4-(1-pyrrolidinyl)-2-pyridone (**15**) in a 12% yield, accompanied by the recovery of **2**.



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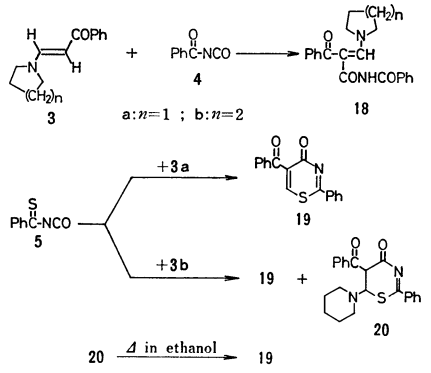
Reaction of Enamino Ketone **3**. The reaction of 1-benzoyl-2-(1-pyrrolidinyl)ethylene (**3a**) with an equimolar quantity of benzoyl isocyanate (**4**) in benzene at room temperature for 2 h afforded 1-benzoyl-1-benzoylcarbamoyl-2-(1-pyrrolidinyl)ethylene (**18a**), mp 171—172 °C (decomp), almost quantitatively. Similarly, 1-benzoyl-2-(1-piperidyl)ethylene (**3b**) reacted with **4** to give the corresponding benzoylcarbamoyl compound **18b**, mp 140—141 °C, in a 75% yield. The structures of **18a** and **18b** were confirmed by the results of microanalyses and their spectral data.

The reaction of **3a** with thiobenzoyl isocyanate (**5**) at room temperature for 2 h afforded a 58% yield of 5-benzoyl-2-phenyl-1,3-thiazin-4-one (**19**), mp 180—181 °C, whose structure corresponded to that of a compound derived from a (4+2) cycloadduct with the elimination of pyrrolidine. **3b** reacted with **5** to give **19** and an 1 : 1 adduct **20**, mp 108—110 °C (decomp),



Scheme 4.

in 9 and 35.5% yields, respectively. The IR spectrum of the 1 : 1 adduct **20** showed no NH absorption bands, and the NMR spectrum in $CDCl_3$ displayed signals at δ 7.2—8.2 (11H, m, aromatic protons and $\rangle$CH) and 8.17 ppm (1H, d, $\rangle$CH, J=7 Hz), besides piperidyl protons. On heating in ethanol **20** was easily converted into the 1,3-thiazine **19**. Thus, **20** is concluded to be the (4+2) cycloadduct, 5,6-dihydro-5-benzoyl-2-phenyl-6-(1-piperidyl)-4*H*-1,4-thiazin-4-one.

Experimental

All the melting points are uncorrected. The NMR spectra were determined with a Hitachi R-20 Model spectrometer, with TMS as an internal standard. The IR spectra were measured as KBr disks, the mass spectra being obtained on a Hitachi RMS-4 mass spectrometer with a direct inlet and an ionization energy of 70 eV.

Materials. 4-(1-Pyrrolidinyl)-3-penten-2-one (**1**) was prepared from acetylacetone and pyrrolidine.[5]

1-Phenyl-3-(1-pyrrolidinyl)-2-buten-1-one (**2**): A solution of 18.0 g of sodium salt of benzoylacetone, prepared from sodium salt of acetophenone and ethyl acetate, and 10.0 g of hydrochloride of pyrrolidine in 100 ml of water was stirred at room temperature for 5 h, during which time crystals precipitated. Filtration gave crystals, which on recrystallization from a mixture of benzene and petroleum ether (bp 60—80 °C) afforded 18.7 g (87%) of enemino ketone **2**, mp 157—158 °C, as yellow prisms. IR spectrum: 1595 (C=O), 1520 cm^{-1} (C=C). NMR spectrum ($CDCl_3$): δ ppm 1.97, 3.43 (each 4H, m, CH_2), 2.68 (3H, s, CH_3), 5.62 (1H, s, =CH), 7.3—8.0 (5H, m, aromatic protons). Mass spectrum: *m/e* 215 (M^+). Found: C, 78.39; H, 7.87; N, 6.42%. Calcd for $C_{14}H_{17}NO$: C, 78.10; H, 7.96; N, 6.51%.

1-Benzoyl-2-(1-pyrrolidinyl)ethylene (**3a**) and 1-benzoyl-2-(1-piperidyl)ethylene (**3b**) were prepared from sodium salt of benzoylacetaldehyde prepared from sodium salt of acetophenone and ethyl formate, and the corrseponding hydrochlorides of amines. **3a**: Mp 118—119 °C, pale yellow prisms. IR spectrum: 1630 (C=O), 1540 cm^{-1} (C=C). NMR spectrum ($CDCl_3$): δ ppm 1.93, 3.90 (each 4H, m, CH_2), 6.10, 8.66 (each 1H, d, =CH, J=12Hz), 7.3—8.2 (5H, m, aromatic protons). Mass spectrum: *m/e* 201 (M^+). Found: C, 77.29; H, 7.36; N, 7.04%. Calcd for $C_{13}H_{15}NO$: C, 77.58; H, 7.51; N, 6.96%. **3b**: Mp 89—90 °C (lit,[7] mp 80—81 °C).

Benzolyl isocyanate (**4**) was prepared by the reported method.[8] In order to prepare thiobenzoyl isocyanate (**5**), a solution of 2-phenylthiazoline-4,5-dione in xylene was heated at 120 °C, giving a reddish-violet solution of **5** which was used *in situ*.[9]

Reaction of Enamino Ketone **1** *with Benzoyl Isocyanate (***4***).* *i*) A solution of 1.53 g (0.01 mol) of enamino ketone **1** and 1.47 g (0.01 mol) of the isocyanate **4** in 30 ml of benzene was stirred at room temperature for 6 h. Filtration gave 0.35 g of 1,2-dibenzoylurea. The filtrate was chromatographed on alumina using benzene as the eluent to give 0.98 g (35%) of 3-acetyl-6-phenyl-4-(1-pyrrolidinyl)-2-pyridone (**7**), mp 264—266 °C (decomp), as colorless prisms, 0.2 g of benzamide, and 0.25 g of unreacted **1** respectively.

The pyridone **7**: NMR spectrum ($CDCl_3$) δ ppm 1.92, 3.22 (each 4H, m, CH_2), 2.62 (3H, s, CH_3), 6.10 (1H, s, =CH), 7.3—8.0 (5H, m, aromatic protons), 12.27 (1H, br, NH). Mass spectrum: *m/e* 282 (M^+), 267 (M^+—NH, base peak), 254 (M^+—CO), 239 (M^+—HNCO). Found: C, 72.07; H, 6.41; N, 9.72%. Calcd for $C_{17}H_{18}N_2O_2$: C, 72.32;

H, 6.43; N, 9.92%.

Compound **7** was identical with a sample prepared from 3-acetyl-6-phenyl-4-(1-pyrrolidinyl)-2-thiopyridone (**8**).[1] After a solution of 30 mg of **8** in 2ml of phosphoryl chloride was refluxed for 1 h, the reaction mixture was poured into ice-water. The resulting solution was alkalized with aqueous potassium hydroxide solution, and then neutralized with hydrochloric acid to give 10 mg of **7**.

ii) After a solution of 1.53 g of **1** and 1.47 g of **4** in 30 ml of benzene was refluxed for 1 h, filtration gave 0.19 g of 1,2-dibenzolylurea. The filtrate was evaporated *in vacuo* and the residue was chromatographed on alumina using chloroform as the eluent to give 0.28 g (12%) of **7** and 0.45 g (15%) of 5-benzoylcarbamyl-4-(1-pyrrolidinyl)-4-penten-2-one (**9**), mp 152—153 °C, as colorless needles. Found: C, 67.88; H, 6.69; N, 9.34%. Calcd for $C_{17}H_{20}N_2O_3$: C, 67.98; H, 6.71; N, 9.33%.

Hydrolysis of the 1:1 Adduct ***9***. A solution of 0.1 g of **9** in 10 ml of 4% ethanolic potassium hydroxide solution was stirred at room temperature for 5 h. The reaction mixture was poured into water, giving crystals. Filtration gave crystals, which on recrystallization from ethanol afforded 45 mg (76%) of 6-methyl-4-(1-pyrrolidinyl)-2-pyridone (**10**), mp 273—275 °C (decomp), as colorless prisms. IR spectrum: 2800—3000 (NH), 1630 cm^{-1} (C=O). NMR spectrum ($CDCl_3$): δ ppm 1.95, 3.27 (each 4H, m, CH_2), 2.28 (3H, s, CH_3), 5.28, 5.51 (each 1H, d, =CH, J=2.5 Hz), 12.9 (1H, br, NH). Mass spectrum: *m/e* 178 (M^+, base peak), 177, 150 (M^+-CO), 135 (M^+-HNCO). Found: C, 67.09; H, 7.90; N, 15.60%. Calcd for $C_{10}H_{14}N_2O$: C, 67.38; H, 7.92; N, 15.72%.

The filtrate was acidified with hydrochloric acid to give 15 mg (37%) of benzoic acid.

Reaction of Enamino Ketone ***1*** *with Thiobenzoyl Isocyanate (****5****).* *i*) A solution of 3.06 g (0.02 mol) of **1** was added to the isocyante **5**, generated from 3.82 g (0.02 mol) of 2-phenylthiazoline-4,5-dione in 50 ml of xylene, and the solution was stirred at room tempreature for 1 h. The reaction mixture was concentrated *in vacuo* to leave a residue, which on chromatography on alumina using chloroform as the eluent gave 0.17 g (3%) of the 2-pyridone **7** and 1.90 g (62%) of unreacted **1**.

ii) The same reaction was followed by NMR spectroscopy. A solution of equimolar quantities of **1** and **5** in nitrobenzene-d_5 was prepared, and its NMR spectrum was measured at room temperature. After *ca.* 30 min, the spectrum showed only signals ascribable to the protons of 3-thiobenzoylcarbamoyl-4-(1-pyrrolidinyl)-3-penten-2-one (**11**) as follows: δ ppm 1.93, 3.0—4.0 (each 4H, m, CH_2), 2.45, 2.63 (each 3H, s, CH_3), 7.2—8.3 (5H, m, aromatic protons), 12.0 (1H, br, NH). After 1 h the formation of **7** was observed, crystals separating out within 5 h.

Reaction of Enamino Ketone ***2*** *with Benzoyl Isocyanate (****4****).* *i*) A solution of 1.0 g (4.65 mmol) of **2** and 0.75 g (5.1 mmol) of **4** in 30 ml of benzene was stirred at room temperature for 5 h, during which time crystals precipitated. Filtration gave crystals, which on recrystallization from a mixture of ethanol and petroleum ether (bp 40—60 °C) below 50 °C afforded 1.45 g (86%) of 2-benzoylcarbamoyl-l-phenyl-3-(1-pyrrolidinyl)-2-buten-1-one (**12**), mp 133—134 °C (decomp.), as colorless needles. IR spectrum: 2800—3000 (NH), 1705, 1655 cm^{-1} (C=O). NMR spectrum ($CDCl_3$): δ ppm 1.95, 3,66 (each 4H, m, CH_2), 2.12 (3H, s, CH_3), 7.2—8.3 (10H, m, aromatic protons), 13.74 (1H, br, NH). Found: C, 73.04; H, 6.06; N, 7.64%. Calcd for $C_{22}H_{22}N_2O_3$: C, 72.91; H, 6.12; N, 7.73%.

ii) A solution of 1.07 g (5 mmol) of **2** and 0.75 g (5.1 mmol) of **4** in 30 ml of benzene was refluxed for 1 h, during which time 0.25 g of 1,2-dibenzoylurea precipitated. The filtrate was concentrated *in vacuo* to leave a residue, which was dissolved in 10 ml of ethanol. The ethanol solution was allowed to stand overnight to give crystals. Filtration gave crystals, which on recrystallization from a mixture of chloroform and petroleum ether (bp 50—60 °C) afforded 0.33 g (17.5%) of 3-benzoyl-6-benzamido-4-(1-pyrrolidinyl)-2-pyrone (**14**), mp 187—188 °C, as colorless needles. NMR spectrum ($CDCl_3$): δ ppm 2.0, 3.65 (each 4H, m, CH_2), 6.65 (1H, s, =CH), 7.3—8.2 (10H, m, aromatic protons), 12.33 (1H, br, NH). Mass spectrum: *m/e* 388 (M^+), 283 (M^+-PhCO), 266 (283^+-OH), 241 ($M^+-PhCONCO$), 213 (241^+-CO), 184, 147 ($PhCONCO^+$), 105 ($PhCO^+$, base peak). Found: C, 70.92; H, 5.20; N, 7.25%. Calcd for $C_{23}H_{20}N_2O_4$: C, 71.12; H, 5.19; N, 7.21%.

The ethanol filtrate was concentrated *in vacuo*, and the reside was recrystallized from a mixture of ethanol and petroleum ether (bp 60—80 °C) to give 0.27 g (15%) of 4-benzoylcarbamoyl-1-phenyl-3-(1-pyrrolidinyl)-3-buten-1-one **13**), mp 141—142 °C, as pale yellow prisms. IR spectrum: 2800—3000 (NH), 1750 cm^{-1} (C=O). NMR spectrum ($CDCl_3$): δ ppm 2.02 4H, m, CH_2), 3.42, 4.0 (each 2H, m, CH_2), 4.22 (2H, s, CH_2), 5.79 1H, s, =CH), 7.3—8.3 (10H, m, aromatic protons), 12.66 (1H, br, NH). Mass spectrum: *m/e* 362 (M^+). Found: C, 72.71; H, 6.06; N, 7.67%. Calcd for $C_{22}H_{22}N_2O_3$: C, 72.91; H, 6.12; 7.73%.

Thermolysis of the 1:1 Adduct ***12***. A solution of 1.0 g of **12** in 20 ml of benzene was refluxed for 1 h. The reaction mixture was then allowed to stand overnight, giving 0.11 g (30%) of 1,2-dibenzoylurea. The filtrate was concentrated *in vacuo*, and the residue was chromatographed on alumina using chloroform as the eluent to give 0.17 g (17%) of **13** and 0.16 g (15%) of **14**. Further elution with ethanol afforded 60 mg (18%) of benzamide.

Hydrolysis of ***12***. A solution of 0.45 g of **12** in 10 ml of 13% ethanolic potassium hydroxide solution was stirred at room temperature for 1 h, during which time crystals precipitated. Filtration gave 0.11 g (33%) of 1,2-dibenzoylurea. The filtrate was neutralized with hydrochloric acid to give crystals, which on recrystallization from ethanol afforded 0.18 g (42%) of 3-benzoyl-6-phenyl-4-(1-pyrrolidinyl)-2-pyridone (**15**), mp 305—307 °C (decomp.), as pale orange needles. IR spectrum: 2800—3000 (NH), 1660 cm^{-1} (C=O). NMR spectrum (DMSO-d_6): δ ppm 1.9, 3.6 (each 4H, m, CH_2), 5.87 (1H, s, =CH), 7.2—8.7 (10H, m, aromatic protons), 11.7—12.0 (1H, br, NH). Mass spectrum: *m/e* 344 (M^+), 327 (M^+-OH), 315 (M^+-COH, base peak). Found: C, 76.95; H, 5.88; N, 7.98%. Calcd for $C_{22}H_{20}N_2O_2$: C, 76.72; H, 5.85; N, 8.13%.

Hydrolysis of the 1:1 Adduct ***13***. A solution of 0.23 g of **13** in 10 ml of 4% ethanolic potassium hydroxide solution was stirred at room temperature for 5 h, and then the reaction mixture was poured into water. The resulting solution was acidified with hydrochloric acid and filtration gave 20 mg (26%) of benzoic acid. The filtrate was neutralized with aqueous sodium hydroxide solution to give crystals, which on recrystallization from ethanol afforded 86 mg (56%) of 6-phenyl-4-(1-pyrrolidinyl)-2-pyridone (**16**), mp 267—269 °C (decomp.), as colorless prisms. IR spectrum: 2800—3000 (NH), 1600—1640 cm^{-1} (C=O and C=C). NMR spectrum ($CDCl_3$): δ ppm 2.0, 3.34 (each 4H, m, CH_2), 5.39, 5.99 (each 1H, d, =CH, J=2.5 Hz), 7.3—8.0 (5H, m, aromatic protons), 9.5—10.5 (1H, br, NH). Mass spectrum: *m/e* 240 (M^+). Found: C, 74.78; H, 6.83; N, 11.55%. Calcd for $C_{15}H_{16}N_2O$: C, 75.00 H, 6.67; N, 11.67%.

Hydrolysis of the Pyrone ***14***. *i*) A solution of 0.2 g of

14 in 10 ml of 13% ethanolic potassium hydroxide solution was stirred at room temperature for 2 h, and then the reaction mixture was poured into 20 ml of water. Filtration gave crystals, which on recrystallization from ethanol afforded 0.14 g (87%) of 5-ethoxycarbonyl-6-phenyl-4-(1-pyrrolidinyl)-2-pyridone (**17**), mp 236—238 °C, as colorless prisms. NMR spectrum ($CDCl_3$): δ ppm 1.33 (3H, t, CH_2CH_3, J=7.2 Hz), 1.96, 3.45 (each 4H, m, CH_2), 4.33 (2H, q, CH_2-Me), 6.02 (1H, s, =CH), 7.2—7.9 (5H, m, aromatic protons), 11.8—12.4 (1H, br, NH). Found: C, 69.01; H, 6.23; N, 9.18%. Calcd for $C_{18}H_{20}N_2O_3$: C, 69.23; H, 6.41; N, 8.97%.

ii) After a suspension of 0.2 g of **14** in 20 ml of 20% aqueous potassium hydroxide solution had been heated under reflux for 1 h, the reaction mixture was poured into water. The resulting solution was neutralized with hydrochloric acid to give crystals, which on recrystallization from ethanol afforded 105 mg (85%) of **16**.

*Reaction of Enamino Ketone **2** with Thiobenzoyl Isocyanate (**5**).* A solution of 2.15 g (0.01 mol) of **2** and **5**, generated from 1.91 g (0.01 mol) of 2-phenylthiazoline-4,5-dione, in 30 ml of xylene was stirred at room temperature for 2 h. The reaction mixture was concentrated *in vacuo* to leave a residue, which on fractional recrystallization from ethanol afforded 0.42 g (12%) of **15** and 0.85 g (40%) of **2**.

*Reaction of Enamino Ketone **3** with Benzoyl Isocyanate (**4**).* A solution of 0.4 g (2 mmol) of the enamino ketone **3a** and 0.3 g (2 mmol) of **4** in 10 ml of benzene was stirred at room temperature for 2 h, during which time crystals precipitated. Filtration gave crystals, which were recrystallized from a mixture of chloroform and petroleum ether (bp 40—60 °C) to give 0.68 g (98%) of 1-benzoyl-1-benzoylcarbamoyl-2-(1-pyrrolidinyl)ethylene (**18a**), mp 171—172 °C (decomp.), as colorless prisms. IR spectrum: 2800—3000 (NH), 1730, 1670 cm^{-1} (C=O). NMR spectrum ($CDCl_3$): δ ppm 1.87 (4H, m, CH_2), 3.21, 3.55 (each 2H, m, CH_2), 7.3—8.3 (11H, m, =CH and aromatic protons), 12.77 (1H, br, NH). Found: C, 72.47; H, 5.78; N, 8.01%. Calcd for $C_{21}H_{20}N_2O_3$: C, 72.39; H, 5.79; N, 8.04%.

Similaly, the reaction of 0.53 g (2.5 mmol) of the enamino keton **3b** with 0.37 g (2.5 mmol) of **4** in 10 ml of benzene afforded 0.68 g (75%) of 1-benzoyl-1-benzoylcarbamoyl-2-(1-piperidyl)ethylene (**18b**), mp 140—141 °C, as colorless prisms. IR spectrum: 2800—3000 (NH), 1720, 1660 cm^{-1} (C=O). NMR spectrum ($CDCl_3$): δ ppm 1.58 (6H, m, CH_2), 3.30 (4H, m, CH_2), 7.3—8.3 (11H, m, =CH and aromatic protons), 12.9 (1H, br, NH). Found: C, 73.11; H, 6.25; N, 7.58%. Calcd for $C_{22}H_{22}N_2O_3$: C, 72.91; H, 6.12; N, 7.73%.

*Reaction of Enamino Ketone **3** with Thiobenzoyl Isocyanate (**5**).* A solution of 1.01 g (5 mmol) of **3a** and **5**, generated from 0.95 g (5 mmol) of 2-phenylthiazoline-4,5-dione, in 30 ml of xylene was stirred at room temperature for 2 h. The reaction mixture was evaporated *in vacuo* to leave a residue, which was triturated with petroleum ether to give crystals. Recrystallization from ethanol afforded 0.85 g (58%) of 5-benzolyl-2-phenyl-1,3-thiazin-4-one (**19**), mp 180—181 °C, as colorless prisms. IR spectrum: 1670, 1630 cm^{-1} (C=O). NMR spectrum ($CDCl_3$): δ ppm 7.2—8.3 (10H, m, aromatic protons), 8.21 (1H, s, =CH). Found: C, 69.69; H, 3.72; N, 4.90%. Calcd for $C_{17}H_{11}NO_2S$: C, 69.62; H, 3.78; N, 4.72%.

Similarly, the reaction of 1.07 g (5 mmol) of **3b** with **5**, generated from 0.95 g (5 mmol) of 2-phenylthiazoline-4,5-dione, in 30 ml of xylene afforded 0.13 g (9%) of **19** and 0.67 g (35.5%) of 5,6-dihydro-5-benzoyl-2-phenyl-6-(1-piperidyl)-4*H*-1,3-thiazin-4-one (**20**), mp 108—110 °C (decomp.), as pale pink crystals. IR spectrum: 1670 cm^{-1} (C=O). NMR spectrum ($CDCl_3$): δ ppm 1.55 (6H, m, CH_2), 3.25 (4H, m, CH_2), 7.2—8.2 (11H, m, >CH and aromatic protons), 8.17 (1H, d, >CH, J=7 Hz). Found: C, 69.75; H, 5.83: N, 7.69%. Calcd for $C_{22}H_{22}N_2O_2S$: C, 69.82; H, 5.86; N, 7.40%.

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