Anal. Calcd for $C_9H_{14}N_2O_2$: C, 59.32; H, 7.74; N, 15.37. Found: C, 59.41; H, 7.87; N, 15.32.

From Acetylation of 36a. 1-Amino-*cis*-perhydrobenz[*c*]azetidin-2-one (**36a**) was acetylated in a manner similar to that described for the acetylation of compound **7** to give **5**. A 90% yield of an oil was isolated which was shown to be **34a** by ir, ^{1}H NMR, and TLC comparison to **34a** obtained from the irradiation of **33a**.

1-Amino-*cis*-perhydrobenz[*c*]azetidin-2-one (36a). To a solution of *cis*-perhydrobenz[*c*]azetidin-2-one (**35a**, 0.69 g, 0.56 mmol) in tetrahydrofuran (which was freshly distilled from lithium aluminum hydride) under a nitrogen atmosphere and cooled to 0° was added over a 10-min period 2.6 *M* BuLi (0.216 ml). The resultant heterogeneous mixture was then stirred for 1 hr at 0°, after which a solution of *O*-mesitylene sulfonylhydroxylamine in tetrahydrofuran (1 ml) was added over a 5-min period. The resultant solution was stirred at 0° for 10 min and then poured in ice-cold aqueous 2 *N* K_2CO_3 (20 ml). The aqueous mixture was extracted with CCl_3H which was dried over K_2CO. Evaporation of the solvent left an oil which was column chromatographed on silicic acid with Et_2O–EtOH (80:20 mixture by volume) eluent. From the column was obtained 11 mg (14%) of an oil which was identified as **36a**: ir (CCl_3H) 2930, 1745 cm^{-1}; ^{1}H NMR (CCl_3D) δ 1.20–2.00 (m, 8), 2.92–3.16 (m, 1), 3.68–3.88 (m, 1), 3.92 (broad s, 2 NH_2); mass spectrum (70 eV) *m/e* (rel intensity) 140 (81, M^+), 109 (22), 108 (46), 82 (37), 81 (100), 67 (80), 54 (47), 41 (41).

Compound **36a** was acetylated to give **34a** for which a correct analysis was obtained (see above, **34a**).

Acknowledgment. We wish to thank the National Institutes of Health (Grant AI 10389) for support of this work.

Registry No.—**1a**, 56700-30-2; **1b**, 56700-31-3; **1c**, 56700-32-4; **1d**, 56700-33-5; **2a**, 56700-34-6; **2b**, 56700-35-7; **2c**, 56700-36-8; **2d**, 56700-37-9; **3**, 56700-38-0; **4**, 56700-39-1; **5**, 56700-40-4; **6**, 56700-41-5; **7**, 56700-42-6; **8**, 56700-43-7; **9**, 56700-44-8; **12**, 56700-45-9; **13a**, 56700-46-0; **13b**, 56700-47-1; **13c**, 56700-48-2; **13d**, 56700-49-3; **14**, 56700-50-6; **15**, 56700-51-7; **17**, 56700-52-8; **20**, 56700-53-9; **21**, 52662-41-6; **21** *p*-toluenesulfonic acid hydrazone, 56700-54-0; **22**, 56700-55-1; **24**, 1617-22-7; **26a**, 56700-56-2; **26b**, 56700-57-3; **27**, 56700-58-4; **28a**, 56700-59-5; **29**, 56700-60-8; **31a**, 56700-61-9; **33a**, 56700-62-0; **34a**, 56700-63-1; **35a**, 22031-53-4; **36a**, 56700-64-2; hydrazine, 302-01-2; cyclohexylidene acetate, 1552-91-6; 2,2,2-trichloroethoxycarbonyl chloride, 17341-93-4; 5-methylpyrazolidin-3-one, 10234-76-1; 2-mercaptopropionic acid, 79-42-5; ethyl 2-bromoisobutyrate, 600-00-0; α-isobutyric acid-β-propionic acid diethyl ester sulfide, 52662-42-7; 5-ethoxycarbonyl-2,2-dimethyl-3-thiacyclopentan-1-one, 52704-93-5; cyclohex-1-ene-1-carboxylic acid, 636-82-8.

References and Notes

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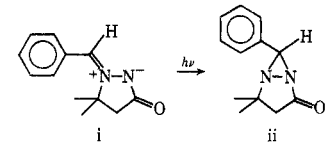

i ii

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Aspects of the Chemistry of 1-Aminoazetidin-2-ones and Pyrazolidin-3-ones

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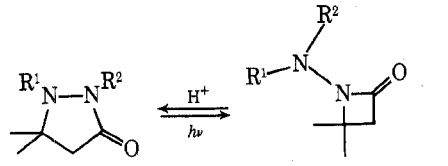
Several reactions of 1-amino-4,4-dimethylazetidin-2-one (**5**) and 1-acetamido-4,4-dimethylazetidin-2-one (**2**) have been examined and their chemistry compared with that of isomeric 5,5-dimethylpyrazolidin-3-ones. The 1-amino β-lactam system was found to undergo ring expansion reactions under a variety of conditions. The irradiation of several 2-alkylpyrazolidin-3-ones to give 1-alkylamino β-lactams in low yields is also discussed.

As part of our work toward the development of approaches to 1-amino- and 1-acylaminoazetidin-2-ones,[1] which we hope to incorporate into total syntheses of penicillin-like systems,[2] we found that these molecules undergo some interesting chemistry, particularly their ring-expansion reactions. While not a well-known class of molecules, 1-aminoazetidin-2-one derivatives have been prepared (1) by photolysis of nitrogen-unsubstituted[1,2] and various 1- or 2-substituted[1,2,3] pyrazolidin-3-ones, (2) by amination of nitrogen unsubstituted azetidin-2-ones,[2,4] (3) by cycloaddition of an acyl hydrazone with ketene,[5] (4) by reaction of an in situ generated 1,1-disubstituted hydrazine with a 3-halo acid chloride,[6] and (5) by an unusual *N*-amino triazole decomposition route.[7]

Results

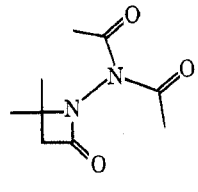
We have previously reported that 2-acetyl-5,5-dimethylpyrazolidin-3-one (1) undergoes photochemical reaction upon irradiation to give 1-acetamidoazetidin-2-one (**2**) in 65% yield.[1] Since that time, we have found that irradiation

Scheme I



	R^1	R^2		R^1	R^2
1	H	CH_3CO	2	H	CH_3CO
3	CH_3CO	H	5	H	H
4	H	H	21	H	CH_3
10	H	CH_3CH_2	22	H	CH_3CH_2
19	H	CH_3			
20	H	CH_2Ph			

of 1-acetyl-5,5-dimethylpyrazolidin-3-one (**3**) gives **2** also, in 30% yield. Furthermore, irradiation of the nitrogen unsubstituted 5,5-dimethylpyrazolidin-3-one (**4**) gives the parent system 1-aminoazetidin-2-one (**5**) in 15% yield. When amine **5** was acetylated under heterogeneous conditions involving acetyl chloride and solid potassium carbonate in methylene chloride at 25°, the desired β-lactam **2** was not obtained but rather a mixture of products was produced from which 1-acetylpyrazolidin-3-one (**3**) was isolated as the major product (see Scheme I). Ring expansion was found not to occur, however, when the reaction was carried out under basic homogeneous conditions. Reaction of **5** with 1 equiv of acetyl chloride in triethylamine allowed isolation of β-lactam **2** in high yield. When 2 equiv of acetyl chloride and triethylamine were employed, diacetylated β-lactam **6** was obtained. We believed that under the hetero-

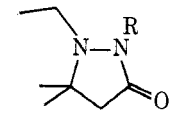


6

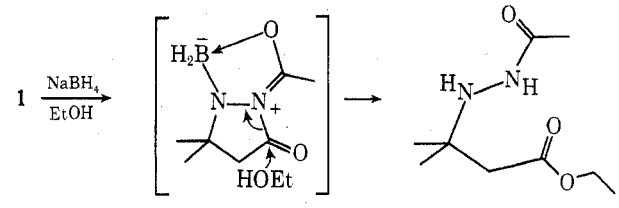
geneous acylation conditions, a low concentration of acid developed which catalyzed the rearrangements of **5**. This contention was supported when it was observed that treatment of 1-aminoazetidin-2-one (**5**) with ethanol–HCl for several hours at 25° resulted in the formation of pyrazolidin-3-one (**4**). Furthermore, 1-acetamidoazetidin-2-one (**2**) underwent a similar reaction to give **4**. We were unable, however, to decide whether hydrolysis of the acetyl group of **2** occurred before or after rearrangement since 2-acetylpyrazolidin-3-one (**1**) also hydrolyzes to give **4** when treated under similar conditions.

In contrast to their behavior under acidic conditions, β-lactams **2** and **5** were shown to be stable to mild base such as sodium ethoxide in ethanol for several hours at 25° or sodium borohydride ($NaBH_4$) in ethanol for 1 hr at 0°. β-Lactams **2**, **5**, and **6** were also thermally stable, since ir spectra of GLC collected samples (200°C) were identical with ir spectra of samples obtained by column chromatography using silicic acid.

While 1,2-diacylhydrazides **2** and **3** were stable to $NaBH_4$ in ethanol at 0°, 1,1-diacylhydrazide **1** reacted to give hydrazide ester **7** as the major product along with two unidentified minor products.[8] Since neither 1-ethyl-2-acetyl-5,5-dimethylpyrazolidin-3-one (**8**), prepared from 1-ethyl-5,5-dimethylpyrazolidin-3-one (**9**), nor 2-ethyl-5,5-dimethylpyrazolidin-3-one (**10**) reacted under similar conditions, we feel that a complexed species such as **11** might have been important in facilitating the reaction of **1**.

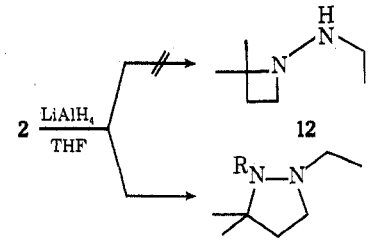


8, R = CH_3CO; **9**, R = H



11 **7**

More vigorous reduction of acetamido β-lactam **2** using lithium aluminum hydride in refluxing tetrahydrofuran did not give the expected azetidine **12** but rather gave 2-ethyl-5,5-dimethylpyrazolidine (**13**) resulting not only from reduction but also rearrangement. Because this trialkylhydrazine was readily oxidized in air, it was converted to its 1-benzoyl derivative **14**.[9] The reduction–rearrangement product **13** was synthesized unequivocally by $LiAlH_4$ reduction of 2-ethyl-5,5-dimethylpyrazolidin-3-one (**10**) prepared via 1-benzoyl-5,5-dimethylpyrazolidin-3-one (**15**)[10] as described below. These reactions were found necessary at early stages of our work to ensure correct assignment of rearrangement isomers.



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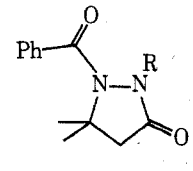
13, R = H; **14**, R = PhCO

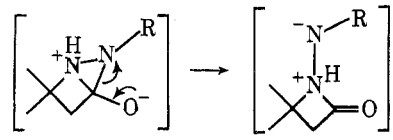
Finally, to complete our photochemical studies on pyrazolidin-3-ones with various N substituents, the photochemistry of several 2-alkylpyrazolidin-3-ones was examined. The 2-methyl- (**19**), 2-ethyl- (**10**), and 2-benzyl- (**20**) 5,5-dimethylpyrazolidin-3-ones were synthesized by alkylation of **15**,[10] to give **16–18**, followed by removal of the benzoyl



15, R = H; **16**, R = Et; **17**, R = Me; **18**, R = CH_2Ph

groups using acid hydrolysis. Irradiation of either the methyl **19** or ethyl **10** compound for 20 hr in degassed methanol with a Hanovia 450-W immersion lamp equipped with a Vycor filter allowed isolation, after careful column chromatography, of alkylamino β-lactams **21** and **22** in low yields (5% at best; see Scheme I). These β-lactams were characterized by their spectral properties (see Experimental Section). Although loss of starting material was not complete after 20 hr in these photolyses, longer irradiation times or variation of other parameters did not improve the yields of β-lactam. In contrast to **19** and **10**, irradiation of 2-benzyl 5,5-dimethylpyrazolidin-3-one (**20**) under a variety of conditions gave no β-lactam product. In this case 1- and 1,2-dibenzyl substituted pyrazolidin-3-ones were isolated in varying yields. Apparently cleavage of the 2-benzyl

group competed effectively with ring contraction. A similar problem was encountered in the photolysis of 2-phenylacetyl-5,5-dimethylpyrazolidin-3-one.[11] Photolysis results obtained for the 2-alkylpyrazolidin-3-ones are in line with the electron transfer quenching mechanism proposed for the photochemical ring contraction reaction of other 2-substituted pyrazolidin-3-ones.[1] If group R (the original 2 substituent) in intermediate **23** can stabilize the negative charge in ylide **24** (e.g., an acyl moiety), good yields of β-lactam are usually obtained. On the other hand, R groups which cannot stabilize the negative charge of ylide **24** (e.g., an alkyl moiety) result in low yields of β-lactam even with longer irradiation times. In these cases side reactions often become important.



23 **24**

Experimental Section

Melting points were taken in capillary tubes on a Thomas-Hoover Unimelt and are uncorrected. Infrared spectra were recorded on a Perkin-Elmer 457 A spectrometer. The ^1H NMR spectra were taken either on a Varian A-60 spectrometer or on a Perkin-Elmer JEOL MH-100 spectrometer and are reported in parts per million downfield from tetramethylsilane. Mass spectra were determined on a Perkin-Elmer Hitachi RMU-6D spectrometer. Ultraviolet spectra were taken on a Cary 14 recording spectrometer. Gas chromatography was carried out using programmed temperature control on a Hewlett-Packard 5750 B instrument equipped with 8- and 10-ft stainless steel columns packed with SE-30 on 80–100 mesh Chromosorb W. Mallinckrodt AR 100 mesh silicic acid was used for all column chromatography. Microanalyses were performed by Galbraith Laboratories, Knoxville, Tenn. Irradiations were carried out using a Hanovia 450-W immersion lamp equipped with a Vycor filter unless otherwise specified.

1-Diacetylamino-4,4-dimethylazetidin-2-one (6). To a solution of 1-acetamido-4,4-dimethylazetidin-2-one (**2**, 0.156 g, 1.00 mmol) and triethylamine (0.101 g, 1.00 mmol) in a mixture of benzene (5 ml) and tetrahydrofuran (2 ml) under nitrogen was added with cooling acetyl chloride (0.078 g, 1.00 mmol) in benzene (1 ml) over a period of 30 min. The mixture was stirred for 8 hr at room temperature, after which the triethylamine hydrochloride salt was filtered off, washed with a little benzene, and the combined filtrates concentrated. The residue was taken up in ice-cold aqueous 2 *N* sodium hydroxide and extracted well with chloroform. The chloroform was dried over K_2CO_3 and evaporated to leave a white solid. Recrystallization of the solid from Et_2O gave 0.106 g (54%) of 1-diacetylamino-4,4-dimethylpyrazolidin-3-one (**6**): mp 92–93°; ir (CCl_3H) no NH, 2960, 1780, 1730, 1319, 1225 (broad), 1100, 1000 cm^{-1}; ^1H NMR (CCl_3D) δ 1.49 (s, 6), 2.43 (s, 6), 2.84 (s, 2); mass spectrum (70 eV) *m/e* (rel intensity) 198 (trace, M^+), 157 (9), 156 (35), 114 (66), 101 (8), 100 (10), 99 (75), 83 (18), 72 (20), 56 (17), 55 (16), 43 (100), 42 (12), 41 (17).

Anal. Calcd for $C_9H_{14}N_2O_3$: C 54.53; H, 7.13; N, 14.13. Found: C, 54.73; H, 7.26; N, 13.98.

Ethyl 3-(2′-Acetylhydrazino)-3-methylbutyrate (7). To a solution of 2-acetyl-5,5-dimethylpyrazolidin-3-one[1] (**2**, 1.00 g, 6.5 mmol) in ethanol (40 ml) cooled to 0° under a nitrogen atmosphere was added $NaBH_4$ (1.32 g, 39.0 mmol) all at once. After stirring for 1 hr the mixture was poured into ice-cold water (40 ml) and extracted with chloroform. The chloroform was dried over K_2CO_3 and evaporated to leave an oil. Column chromatography of the oil in silicic acid with Et_2O–EtOH (90:10 mixture by volume) eluent resulted in the isolation of 598 mg (45%) of an oil which was shown to be pure **7**: ir (CCl_3H) 3430, 2960, 1720, 1670, 1370, 1320, 1110, 1022, 850 cm^{-1}; ^1H NMR (CCl_3D) δ 1.18 (s, 6), 1.26 (t, *J* = 7 Hz, 3), 1.98 (s, 3), 2.39 (s, 2), 4.11 (q, *J* = 7 Hz, 2); mass spectrum (70 eV) *m/e* (rel intensity) no parent ion, 156 (10), 114 (50), 99 (100), 83 (10), 72 (10), 56 (10), 55 (8), 43 (25).

Anal. Calcd for $C_9H_{18}N_2O_3$: C, 53.44; H, 8.97; N, 13.85. Found: C, 53.26; H, 9.06; N, 13.83.

2-Acetyl-1-ethyl-5,5-dimethylpyrazolidin-3-one (8). To a solution of 1-ethyl-5,5-dimethylpyrazolidin-3-one (**9**, 1.00 g, 7.1 mmol) and triethylamine (0.72 g, 7.1 mmol) in tetrahydrofuran (100 ml) was added dropwise a solution of acetyl chloride (0.56 g, 7.1 mmol) in tetrahydrofuran (5 ml). The mixture was stirred at room temperature for 6 hr, after which it was filtered to remove the precipitated triethylamine hydrochloride salt. Evaporation of the solvent left an oil which was column chromatographed on silicic acid using Et_2O–EtOH (90:10 mixture by volume) eluent to give 0.74 g (58%) of a pure oil which was identified as **8**: ir (CCl_3H) 2970, 1750, 1710, 1375, 1305, 1230 (broad), 1130, 1085, 955, 945 cm^{-1}; ^1H NMR (CCl_3D) δ 1.10 (t, *J* = 7 Hz, 3), 1.35 (s, 6), 2.50 (s, 3), 2.52 (s, 2), 3.04 (q, *J* = 7 Hz, 2); mass spectrum (70 eV) *m/e* (rel intensity) 184 (trace, M^+), 143 (3), 142 (31), 129 (7), 128 (100), 109 (5), 99 (14), 85 (2), 83 (5), 71 (2), 56 (5), 55 (4), 43 (12), 42 (6), 41 (7); uv (EtOH) end absorption 200 nm (ε 3200), 227 (3800), 262 (1000).

Anal. Calcd for $C_9H_{16}N_2O_2$: C, 58.67; H, 8.75; N, 15.21. Found: C, 58.51; H, 8.87; N, 15.03.

1-Ethyl-5,5-dimethylpyrazolidin-3-one (9). To a solution of 1-benzoyl-5,5-dimethylpyrazolidin-3-one[10] (**15**, 11.4 g, 0.10 mol) in EtOH (150 ml) cooled to 10° under a nitrogen atmosphere was added all at once acetaldehyde (13.2 g, 0.30 mol). The resulting solution was stirred at room temperature for 1 hr and then cooled to 0°. To the cooled solution was added $NaBH_4$ (20 g, 0.53 mol) in several portions at short intervals. After the last addition the mixture was allowed to warm to room temperature and to stir at that temperature for 30 min. The solution was again cooled and water was added. The mixture was extracted well with chloroform which was dried over K_2CO_3. Evaporation of the solvent left a solid. Column chromatography of the solid on silicic acid using Et_2O–EtOH (90:10 mixture by volume) eluent gave 4.3 g (30%) of pure **9**: mp 113.5–114.5; ir (CCl_3H) 3430, 2970, 1695, 1370, 1305, 1100 cm^{-1}; ^1H NMR (CCl_3D) δ 1.15 (t, *J* = 7.5 Hz, 3), 1.30 (s, 6), 2.38 (s, 2), 2.71 (q, *J* = 7.5 Hz, 2); mass spectrum (70 eV) *m/e* (rel intensity) 142 (27, M^+), 128 (8), 127 (100), 99 (36), 85 (10), 84 (7), 83 (24), 71 (9), 57 (12) 56 (14), 55 (13), 35 (8), 44 (7), 42 (13), 41 (18).

Anal. Calcd for $C_7H_{14}N_2O$: C, 59.13; H, 9.92; N, 19.70. Found: C, 59.00; H, 10.05; N, 19.77.

2-Ethyl-5,5-dimethylpyrazolidin-3-one (10). A solution of 1-benzoyl-2-ethyl-5,5-dimethylpyrazolidin-3-one (**16**, 20.0 g, 0.082 mol) in a mixture of 12 *N* aqueous HCl (240 ml) and EtOH (80 ml) was refluxed under a nitrogen atmosphere for 20 hr. The solution was washed with Et_2O, after which it was cooled in an ice bath and solid NaOH was added to it until the pH was strongly basic. The basic water was extracted well with CCl_3H which was dried over K_2CO_3. Evaporation of the solvent left an oil which upon distillation gave 8.84 g (76%) of pure **10**: bp 65° (1 mm); ir (CCl_3H) 2920, 1680, 1460, 1400, 1300, 940, 910, 887 cm^{-1}; ^1H NMR (CCl_3D) δ 1.12 (t, *J* = 7 Hz, 3), 1.25 (s, 6), 2.31 (s, 2), 3.41 (q, *J* = 7 Hz, 2), 4.88 (broad s, 1, NH); mass spectrum (70 eV) *m/e* (rel intensity) 142 (51, M^+), 127 (66), 99 (58), 85 (90), 83 (81), 58 (42), 56 (100), 55 (36), 43 (50), 41 (42); uv (EtOH) 206 nm (ε 5330), 222 (3765).

Anal. Calcd for $C_7H_{14}N_2O$: C, 59.13; H, 9.92; N, 19.70. Found: C, 59.14; H, 9.82; N, 19.70.

2-Benzoyl-1-ethyl-3,3-dimethylpyrazolidine (14). From 2. To a solution of 1-acetamido-4,4-dimethylazetidin-2-one[1] (**2**, 0.100 g, 0.640 mmol) in tetrahydrofuran (3 ml) cooled to 0° under a nitrogen atmosphere was added in several portions lithium aluminum hydride (0.292 g, 7.7 mmol). The mixture was allowed to warm to room temperature during a period of 30 min after which it was refluxed for 24 hr. At the end of the reflux period the mixture was cooled in an ice bath and water (10 ml) was added. The aqueous mixture was extracted well with Et_2O which was dried over K_2CO_3. Evaporation of the solvent left an oil which was taken up in methylene chloride (5 ml). In this solution cooled to 10–20°C under a nitrogen atmosphere was suspended a small quantity of anhydrous K_2CO_3. Benzoyl chloride (0.200 g, 14.0 mmol) was then added to the suspension and the resultant mixture stirred at room temperature for 6 hr. At the end of the reaction period the mixture was filtered and to the filtrate, cooled in an ice bath, was added aqueous 2 *N* HCl (approximately 4 ml). The mixture was extracted twice with Et_2O. To the aqueous layer, cooled in an ice bath, was added aqueous 2 *N* NaOH (approximately 6 ml). The resulting solution was extracted well with chloroform which was dried over K_2CO_3. Evaporation of the solvent left 0.030 g of an oil which was identified to be **14** (20% based on **2**) by comparison to **14** prepared by reduction–benzoylation of 2-ethyl-5,5-dimethylpyrazolidin-3-one (**10**).

From 10. To a suspension of lithium aluminum hydride (26.0 mmol, 1.00 g) in tetrahydrofuran (25 ml) cooled to 0° under a ni-

trogen atmosphere was added a solution of 1-ethyl-5,5-dimethylpyrazolidin-3-one (**10**, 7.00 mmol, 1.00 g) in tetrahydrofuran (5 ml) over a period of 30 min. The mixture was allowed to warm to room temperature during a period of 30 min after which it was refluxed for 40 hr. At the end of the reflux period the mixture was cooled in an ice bath and water (25 ml) was added. The mixture was extracted with chloroform which was dried over K_2CO_3. Evaporation of the solvent left an extremely air-sensitive oil. Distillation of the oil gave 0.576 g (64%) of 1-ethyl-3,3-dimethylpyrazolidine (**13**): ^1H NMR (CCl_3D) δ 1.11 (t, J = 7.5 Hz, 3), 1.22 (s, 6), 1.79 (t, J = 7 Hz, 2), 2.65 (q, J = 7.5 Hz, 2), 2.78 (t, J = 7 Hz, 2).

To a solution of 1-ethyl-3,3-dimethylpyrazolidine (**13**, 0.500 g, 3.90 mmol) in aqueous 1 N NaOH (5 ml) cooled to 10° under a nitrogen atmosphere was added dropwise benzoyl chloride (0.550 g, 3.90 mmol). After the addition was complete the mixture was allowed to warm to room temperature and was stirred for 6 hr. At the end of the reaction period the mixture was extracted well with chloroform which was dried over K_2CO_3. Evaporation of the solvent left 0.154 g (11% based on **10**) of an oil which was shown to be pure **14**: ir (CCl_4) 2970, 1645, 1410, 1245, 1135, 1025, 910 cm^{-1}; ^1H NMR (CCl_3D) δ 0.68 (t, J = 7 Hz, 3), 1.68 (s, 6), 2.16 (t, J = 8 Hz, 2), 2.63 (q, J = 7 Hz, 2), 3.08 (t, J = 8 Hz, 2), 7.28–7.48 (m, 3), 7.68–7.88 (m, 2); mass spectrum (70 eV) m/e (rel intensity) 232 (5, M^+), 128 (9), 127 (100), 122 (4), 105 (9), 99 (10), 97 (6), 77 (15), 70 (3), 56 (7), 55 (5), 51 (7), 44 (3), 43 (7), 42 (7), 41 (8).

Anal. Calcd for $C_{14}H_{20}N_2O$: C, 72.38; H, 8.68; N, 12.06. Found: C, 72.06; H, 8.74; N, 12.03.

1-Benzoyl-2-ethyl-5,5-dimethylpyrazolidin-3-one (16). To a solution of 1-benzoyl-5,5-dimethylpyrazolidin-3-one[10] (**15**, 38.5 g, 0.176 mol) in 0.4 N ethanolic NaOH (75 ml) under a nitrogen atmosphere was added ethyl iodide (27.5 g, 0.176 mol). The resultant solution was heated to 80° for 12 hr and then cooled. Evaporation of the solvent left a solid which was taken up in water (100 ml). The water was extracted with CCl_3H which was dried over K_2CO_3 and evaporated to leave a white solid which was recrystallized from Et_2O to give 21.1 g (49%) of pure **16**: mp 146–147°; ir (CCl_3H) 2960, 1715, 1670, 1340, 1290, 1245, 1175, 1080 cm^{-1}; ^1H NMR (CCl_3D) δ 1.15 (t, J = 7.5 Hz, 3), 1.28 (s, 6), 2.49 (s, 2), 3.72 (q, J = 7.5 Hz, 2), 7.3–7.8 (m, 5); mass spectrum (70 eV) m/e (rel intensity) 246 (5, M^+), 141 (13), 106 (9), 105 (100), 99 (8), 83 (5), 77 (24), 56 (4), 55 (3), 51 (7), 43 (4), 42 (3), 41 (4).

Anal. Calcd for $C_{14}H_{18}N_2O_2$: C, 68.27; H, 7.37; N, 11.37. Found: C, 68.58; H, 7.43; N, 11.30.

1-Benzoyl-2,5,5-trimethylpyrazolidin-3-one (17). To a solution of 1-benzoyl-5,5-dimethylpyrazolidin-3-one[10] (**15**, 9.50 g, 43.5 mmol) in aqueous 2 N NaOH (22 ml) cooled to 10–20° under a nitrogen atmosphere was added dropwise over a period of 30 min dimethyl sulfate (5.50 g, 43.5 mmol). After the addition the mixture was allowed to warm to room temperature and to stir for 6 hr. The mixture was then extracted with CCl_3H which was dried over K_2CO_3 and evaporated to leave a white solid. Recrystallization of the solid from Et_2O gave 6.55 g (65%) of pure **17**: mp 125–126°; ir (CCl_4) 2970, 1715, 1665, 1415, 1325, 1275, 1170, 1090, 945 cm^{-1}; ^1H NMR (CCl_3D) δ 1.29 (s, 6), 2.51 (s, 2), 3.18 (s, 3), 7.30–7.85 (m, 5); mass spectrum (70 eV) m/e (rel intensity) 232 (7, M^+), 127 (25), 106 (28), 105 (100), 85 (39), 83 (15), 78 (11), 77 (75), 56 (26), 55 (17), 51 (45), 50 (13), 44 (14), 43 (28), 42 (17), 41 (27).

Anal. Calcd for $C_{13}H_{16}N_2O_2$: C, 67.22; H, 6.94; N, 12.06. Found: C, 67.39; H, 6.90; N, 12.12.

1-Benzoyl-2-benzyl-5,5-dimethylpyrazolidin-3-one (18). A solution of 1-benzoyl-5,5-dimethylpyrazolidin-3-one[10] (**15**, 12.90 g, 0.059 mol) and benzyl bromide (9.90 g, 0.059 mol) in 0.4 N ethanolic NaOH (188 ml) was refluxed for 7 hr. After cooling the solution was stripped to leave a white solid to which was added ice-cold water (100 ml). After stirring for 15 min the undissolved solid was filtered off and washed with a little ether. Recrystallization from ether–ethanol gave 9.10 g (50%) of pure **18**: mp 176–177°; ir (CCl_3H) 3030, 2960, 1715, 1660, 1450, 1420, 1380, 1340, 1275, 1245, 1180 cm^{-1}; ^1H NMR (CCl_3D) δ 1.91 (s, 6), 2.5 (s, 2), 4.94 (s, 2), 7.39 (s, 5), 7.45 (s, 5); mass spectrum (70 eV) m/e (rel intensity) 308 (5, M^+), 205 (1), 204 (5), 203 (6), 162 (1.5), 106 (9.5), 105 (100), 92 (4), 91 (45.5), 77 (24), 65 (4.5), 56 (3), 55 (2), 51 (5), 44 (2), 41 (4).

Anal. Calcd for $C_{19}H_{20}N_2O_2$: C, 74.00; H,6.54; N, 9.09. Found: C, 73.97; H, 6.59; N, 9.14.

2,5,5-Trimethylpyrazolidin-3-one (19). A solution of 1-benzoyl-2,5,5-trimethylpyrazolidin-3-one (**17**, 15.15 g, 65.0 mmol) in a mixture of aqueous 12 N HCl (180 ml) and EtOH (60 ml) was refluxed for 20 hr. After cooling the aqueous solution was washed with Et_2O, cooled in an ice bath, and solid NaOH was added to it until the pH was strongly basic. The basic aqueous solution was extracted well with CCl_3H which was dried over K_2CO_3 and evaporated to leave an oil. Distillation of the oil gave 5.00 g (60%) of pure **19**: bp 51° (0.1 mm); ir (CCl_4) 2960 1690, 1380, 1090 cm^{-1}; ^1H NMR (CCl_3D) δ 1.25 (s, 6), 2.31 (s, 2), 2.99 (s, 3), 5.05 (broad s, 1, NH); mass spectrum (70 eV) m/e (rel intensity) 128 (89, M^+), 113 (100), 85 (12), 84 (39), 82 (51), 72 (14), 57 (28), 56 (86), 55 (39), 46 (28), 45 (32), 44 (21), 43 (26), 42 (61), 41 (61); uv (EtOH) shoulder on end absorption at 214 nm (ϵ 3150).

Anal. Calcd for $C_6H_{12}N_2O$: C, 56.23; H, 9.44; N, 21.86. Found: C, 56.19; H, 9.42; N, 21.69.

2-Benzyl-5,5-dimethylpyrazolidin-3-one (20). A solution of 1-benzoyl-2-benzyl-5,5-dimethylpyrazolidin-3-one (**18**, 15.35 g, 0.050 mol) in a mixture of 12 N aqueous HCl (150 ml) and ethanol (50 ml) was refluxed for 20 hr. After cooling the mixture was extracted with Et_2O to remove the benzoic acid which was formed. The aqueous layer was neutralized with NaOH and extracted again with Et_2O. This Et_2O was dried over K_2CO_3 and distilled to give 5.90 g (60%) of pure **20**: bp 158° (3 mm); ir (CCl_3H) 3030, 2965, 1695, 1390, 1370, 1280 cm^{-1}; ^1H NMR (CCl_3D) δ 1.11 (s, 6), 2.18 (s, 2), 4.35 (broad s, 1, NH), 4.45 (s, 2), 7.30 (s, 5); mass spectrum (70 eV) m/e (rel intensity) 204 (36, M^+), 189 (8), 113 (25), 111 (8), 105 (9), 100 (13), 91 (100), 85 (5), 93 (10), 77 (8), 71 (12), 65 (12), 57 (12), 56 (12), 55 (12), 46 (29), 45 (64), 43 (21), 41 (18); uv (EtOH) shoulder on end absorption at 222 nm (ϵ 3350), 280 (150).

Anal. Calcd for $C_{12}H_{16}N_2O$: C, 70.55; H, 7.90; N, 13.71. Found: C, 70.47, H, 8.03; N, 13.60.

1-Methylamino-4,4-dimethylazetidin-2-one (21). A solution of 2,5,5-trimethylpyrazolidin-3-one (**19**, 1.28 g, 0.010 mol) in methanol (250 ml) was degassed with a stream of nitrogen for 2 hr, after which it was irradiated for 20 hr with a Hanovia 450-W immersion lamp equipped with a Vycor filter. TLC analysis indicated the formation of one product with a slightly greater R_f value than the starting material. (Loss of starting material was not complete but longer irradiation times did not significantly change the ratio). Evaporation of the solvent followed by columns chromatography on silicic acid with Et_2O–EtOH (80:20 mixture by volume) eluent resulted in the isolation of 0.064 g (ca. 5%) of an oil which was identified from its spectra to be **21**: ir (CCl_3H) 2970, 1755, 1378, 1278 cm^{-1}; ^1H NMR (CCl_3D) δ 1.40 (s, 6) 2.56 (s, 2), 2.80 (s, 3), 4.21 (broad s, 1, NH); mass spectrum (70 eV) m/e (rel intensity) 128 (12, M^+), 86 (66), 84 (100), 72 (29), 56 (17), 47 (25), 44 (21).

1-Ethylamino-4,4-dimethylazetidin-2-one (22). A solution of 2-ethyl-5,5-dimethylpyrazolidin-3-one (**10**, 1.42 g, 0.010 mol) in methanol (250 ml) was treated in a manner similar to the reaction of 2,5,5-trimethylpyrazolidin-3-one (**19**) described above. From the column was isolated 0.043 g (3%) of an oil which was identified by its spectra to be **22**: ir (CCl_3H) 2965, 1750 cm^{-1}; ^1H NMR (CCl_3D) δ 1.22 (t, J = 7 Hz, 3), 1.40 (s, 6), 2.50 (s, 2), 3.12 (q, J = 7 Hz, 2), 4.31 (s, 1, NH).

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Registry No.—**2**, 53992-45-3; **6**, 56678-92-3; **7**, 56678-93-4; **8**, 56678-94-5; **9**, 26485-97-2; **10**, 56678-95-6; **13**, 56678-96-7; **14**, 56678-97-8; **15**, 49629-13-2; **16**, 56678-98-9; **17**, 56678-99-0; **18**, 56679-00-6; **19**, 56679-01-7; **20**, 53992-50-0; **21**, 56679-02-8; **22**, 56679-03-9.

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