order and amounts: β-keto ethyl ester, 0.05 g; ketal ethyl ester, 0.41 g; β-keto glycol ester, 0.02 g; ketal glycol ester, 0.18 g. The ketal esters were obtained in a 98% yield, based on consumed starting β-keto esters. Ketal ethyl ester **54**: IR ($CHCl_3$) 5.78, 6.28 μm; UV λ_{max} 237 nm (ε 23 600), 226 (24 300). Anal. Calcd for $C_{19}H_{23}N_3O_6S$: C, 54.2; H, 5.5; N, 10.0. Found: C, 54.3; H, 5.5; N, 10.1.

2-(*N*-Methyl-*p*-toluenesulfonamido)-5-[1,1-ethylenedioxy-2-(ethoxycarbonyl)ethyl]-1,4,5,6-tetrahydropyrimidine (55). To a solution of pyrimidine **54** (1.30 g, 3.1 mmol) in 20 mL of glacial acetic acid was added 6.2 mL of 0.5 M HCl in acetic acid. Platinum oxide (0.5 g) was added, and the mixture was shaken with hydrogen for 10 h, by which time the uptake of hydrogen had ceased. The catalyst was removed, the filtrate was evaporated, and the residual oil was dissolved in chloroform, washed with sodium bicarbonate and NaCl solutions, dried, concentrated to a small volume, and chromatographed (120 g of silica, 3% ethanol/chloroform) to give 1.04 g (2.4 mmol, 79% yield) of **55**: UV λ_{max} 228 nm (ε 17 100); mass spectrum *m/e* 361, 360 ($M^+ - 64$, 65). Anal. Calcd for $C_{19}H_{27}N_3O_6S$: C, 53.6; H, 6.4; N, 9.9. Found: C, 53.6; H, 6.2; N, 9.9.

2-(*N*-Methyl-*p*-toluenesulfonamido)-5-(1,1-ethylenedioxy-3-hydroxypropyl)-1,4,5,6-tetrahydropyrimidine (56). To a solution of THF containing ester **55** (130 mg, 0.3 mmol) was added 1.5 mL of 1 M B_2H_6 in THF, and the solution was stirred at room temperature for 8 h. The excess diborane and organoboron complexes were decomposed with methanol, the solution was concentrated, and the residue was chromatographed on alumina to give 88 mg (0.2 mmol, 73%) of alcohol **56**: mp 119.5–122.0 °C. Anal. Calcd for $C_{17}H_{25}N_3O_5S$: C, 53.3; H, 6.6; N, 11.0. Found: C, 53.0; H, 6.5; N, 10.8.

2-(*N*-Methyl-*p*-toluenesulfonamido)-5-(1,1-ethylenedioxy-3-chloropropyl)-1,4,5,6-tetrahydropyrimidine (57). A mixture composed of alcohol **56** (0.25 g, 0.65 mmol), triphenylphosphine (0.34 g, 1.3 mmol), and 5 mL of carbon tetrachloride (distilled from P_2O_5) was heated to reflux for 6 h.[20,26,27] The reaction mixture was evaporated to dryness, and the residue was dissolved in chloroform and chromatographed (50 g of silica, 3% ethanol/chloroform). Combination of the fractions containing only product gave 90 mg of **57** (0.22 mmol, 34% yield), with 35 mg of product contaminated with triphenylphosphine oxide. Short-path distillation of the eluted material gave **57** as an oil which slowly crystallized (125 mg, 47%), mp 150–158 °C. Anal. Calcd for $C_{17}H_{24}N_3O_4SCl$: C, 50.8; H, 6.0; N, 10.4. Found: C, 50.7; H, 6.1; N, 10.2.

2-(*N*-Methyl-*p*-toluenesulfonamido)-6,6-ethylenedioxy-1,3-diazabicyclo[3.3.1]non-2-ene (33). Tosylamido ketal chloride **57** (86 mg, 0.21 mmol) was dissolved in 10 mL of dry toluene, excess anhydrous potassium carbonate was added, and the mixture was heated at reflux for 48 h. The mixture was cooled and filtered, the filtrate was evaporated to dryness, and the residue was chromatographed on alumina (15 g, neutral, activity III, chloroform) to give 75 mg (94%) of **33**, identical with material prepared from **28** by methylation: mp 184–186 °C, after crystallization from hexane–benzene; NMR δ 1.42 (m, 2 H, $COCH_2$), 1.7 (m, 1 H, methine), 2.33 (s, 3 H, $ArCH_3$), 3.1 (s, 3 H, NCH_3), 2.6–3.6 (m, 4 H, NCH_2CH_2), 3.44 (d, 2 H, NCH_2CH), 3.82 (s, 4 H, OCH_2CH_2O), 7.13 and 7.68 (2 d, 4 H, Ar); IR 6.06 cm^{-1}; UV λ_{max} 226 nm; mass spectrum *m/e* 301, 300 ($M^+ - 64 - 65$), 278, 277. Anal. Calcd for $C_{17}H_{23}N_3O_4S$: C, 55.9; H, 6.3; N, 11.5. Found: C, 55.9; H, 6.1; N, 11.3.

pK_a Determination of Bicyclic Guanidino Ketones. The pK_a's were determined by using a Corning Digital 110 pH meter with a semimicro combination electrode with a triple-purpose glass membrane. Carbon dioxide free water was used to prepare CO_2-free potassium hydroxide (1.0 N) and to dissolve the guanidine hydrochlorides (approximately 100 mg). Titrations were conducted in a closed 100-mL vessel fitted with a rubber stopper which had ports for a buret, thermometer, nitrogen inlet and outlet, and electrode. The procedure as described[15] was used. Compound **30** will be used as an example; all were run in an identical manner. Compound **30** (164 mg, 0.865 mmol) was dissolved in 40 mL of water and then titrated. The results are shown in Table IV. Rows 3–9 give an average pK of 10.78 ± 0.08. The pK_a's for the other guanidines are listed in Table II.

Acknowledgment. This research was supported in part by the National Institute of Environmental Health Sciences.

Registry No. **4**, 1886-67-5; **5b**, 5616-81-9; **6b**, 71766-73-9; **7b**, 71785-29-0; **8**, 71785-28-9; **11**, 2651-15-2; **12**, 6291-84-5; **13**, 71766-74-0; **14**, 71766-75-1; **17**, 23099-21-0; **17**·2HCl, 71766-76-2; **18**, 71766-77-3; **19**, 71766-78-4; **20**, 4451-86-9; **21**, 71785-32-5; **22**, 71766-79-5; **22**·Li, 71766-80-8; **23**, 71785-33-6; **24**, 71766-81-9; **25**, 71766-82-0; **26**, 71766-83-1; **27**, 71766-84-2; **28**, 71766-85-3; **29**, 71766-86-4; **30**, 71766-87-5; **31**, 71766-88-6; **32**, 71766-89-7; **33**, 71766-90-0; **34**, 71766-91-1; **35**, 71766-92-2; **37**, 71766-93-3; **38**, 18805-25-9; **39**, 71766-94-4; **40**, 71766-95-5; **42**, 71766-96-6; **43**, 71766-97-7; **44**, 71766-98-8; **45**, 71766-99-9; **46**, 71767-00-5; **47**, 71767-01-6; **48**, 71767-02-7; **49**, 71767-03-8; **50**, 38653-04-2; **51**, 71767-04-9; **53**, 71767-05-0; **54**, 71767-06-1; **55**, 71798-61-3; **56**, 71798-62-4; **57**, 71767-07-2; 2-methylsulfonimido-3,4-dimethyl-1,3-diazabicyclo-[3.3.1]nonan-6-one, 71767-08-3; 2-methylsulfonimido-3,4-dimethyl-1,3-diazabicyclo[3.3.1]nonan-6,6-diol, 71767-09-4; 2-methylsulfonimido-3,4-dimethyl-1,3-diazabicyclo[3.3.1]nonane, 71767-10-7; potassium *tert*-butoxide, 865-47-4; 3-cyanopyridine, 100-54-9; carbonyldiimidazole, 530-62-1; ethyl hydrogen malonate magnesium complex, 64679-38-5.

(26) J. B. Lee and T. J. Nolan, *Can. J. Chem.*, **44**, 1331 (1966).
(27) J. B. Lee and I. M. Downie, *Tetrahedron*, **23**, 359 (1967).

Reactions of Ketenimines with Nitrones

Otohiko Tsuge,* Hiroyuki Watanabe, Kichiro Masuda, and Mohamed M. Yousif

Research Institute of Industrial Science, Kyushu University 86, Hakozaki, Higashi-ku, Fukuoka 812, Japan

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Dimethylketene-*N*-phenylimine reacts with benzylideneaniline *N*-oxides and cinnamylideneaniline *N*-oxide to give the corresponding 1:1 adducts, 1-(*o*-(benzylideneamino)phenyl)-1,1-dimethylacetanilides, which are easily hydrolyzed to 3,3-dimethyloxindole, whereas the reaction of the ketenimine with cyclic nitrones such as 1-pyrroline 1-oxides afforded 1:1 adducts, imidazolidinone and/or diazaspiro[4.4]nonanone derivatives. In the reaction of diphenylketene-*N*-phenylimine with cyclic nitrones, a perhydropyrrooxadiazinone or imidazolidinone is formed, depending on the nature of cyclic nitrones.

During the course of the study on the reaction of 1,2-diphenyl-1-azaspiro[2.2]pentane with benzylideneaniline *N*-oxide, we found that phenylketene-*N*-phenylimine, generated in situ from the azaspiropentane, reacted with the nitrone to give 2,3,4,5-tetrahydro-2,3,5-triphenyl-1*H*-benzo[*f*]-1,3-diazepin-4-one and its ring opening isomer,

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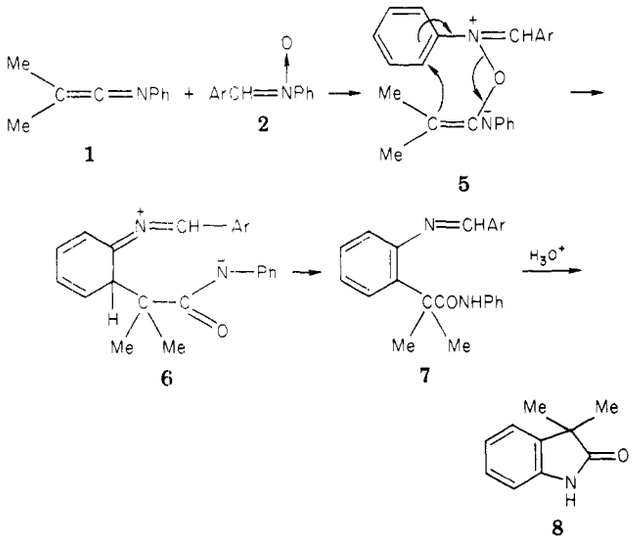
Scheme I



a, Ar = Ph; b, Ar = *p*-$MeOC_6H_4$; c, Ar = *p*-ClC_6H_4; d, Ar = *p*-$O_2NC_6H_4$; e, Ar = PhCH=CH

1-(*o*-(benzylideneamino)phenyl)-1-phenylacetanilide.[1] Although a few reactions of *N*-arylketenimines with the nitrone have appeared in the literature, no formation of such compounds as the benzo[*f*]-1,3-diazepinone and its ring opening isomer has so far been reported. Therefore, we were interested in studying the reaction of *N*-arylketenimines other than phenylketene-*N*-phenylimine with nitrones.

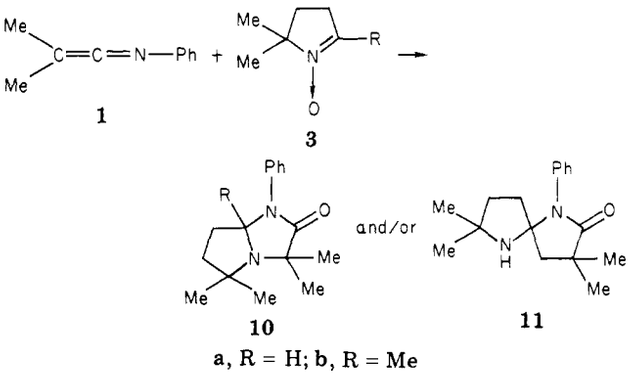
After it had been found[2] that the 1:1 adduct of diphenylketene-*N*-arylimine to benzylideneaniline *N*-oxide was the imidazolidinone and not the isoxazolidinone proposed previously,[3] the same imidazolidinone structure was independently assigned for the 1:1 adduct of diphenylketene-*N*-*p*-bromophenylimine to the nitrone.[4] We wish to report here our findings on the reactions of dimethylketene-*N*-phenylimine (**1**) with benzylideneaniline *N*-oxides (**2**) and cyclic nitrones such as 1-pyrroline 1-oxides (**3**). In this context, the reaction of diphenylketene-*N*-phenylimine (**4**) with cyclic nitrones **3** is also described.

Results and Discussion

Reaction of Dimethylketene-*N*-phenylimine (1) with Benzylideneaniline *N*-Oxides (2). Recently, Ohshiro and his co-workers[4] reported that the ketenimine **1** reacted with benzylideneaniline *N*-oxide (**2a**) in boiling benzene to give 3,3-dimethyloxindole (**8**) instead of a 1:1 adduct. However, our present study has revealed that the 1:1 adduct is isolable in the reaction of the ketenimine **1** with the nitrone **2**.

When the ketenimine **1** was allowed to react with the nitrone **2a** in boiling benzene, the 1:1 adduct **7a**, 1-(*o*-(benzylideneamino)phenyl)-1,1-dimethylacetanilide, was obtained in 84% yield. Similarly, the ketenimine **1** reacted with para-substituted benzylideneaniline *N*-oxides **2b–d** and cinnamylideneaniline *N*-oxide (**2e**) to afford the corresponding 1:1 adducts **7b–e** in 57–82% yields. Structural elucidation of the adducts **7a–e** was accomplished on the basis of spectral data.

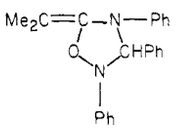
Scheme II



a, R = H; b, R = Me

The formation of the adducts **7** can be satisfactorily interpreted in terms of the reaction sequence shown in Scheme I. The process leading to **7** involves the initial formation of the zwitterion **5**, followed by a sigmatropic rearrangement of **5** to the zwitterion **6** with subsequent hydrogen transfer. A similar reaction sequence has been proposed for the formation of iminocarboxylic acids from ketenes and *N*-arylnitrones.[5]

The adducts **7**, even on chromatography, were readily hydrolyzed to give the oxindole **8**, and these adducts were therefore not observed in the previous work[4] since the product from the ketenimine **1** and nitrone **2a** was subjected to chromatography (Al_2O_3, benzene–ethanol). Although it has been proposed that the oxindole **8** was formed by a decomposition of the labile cycloadduct **9** which arose from the zwitterion **5** (Ar=Ph),[4] cycloadducts such as **9** have never been isolated in the reactions of either



9

ketenes or ketenimines with nitrones. The cycloadduct **9** does not seem to be a plausible precursor of **8**. It is reasonable to conclude that **8** is not a direct product from **1** and **2a**, as was claimed in the previous work, and is derived from hydrolysis of **7**.

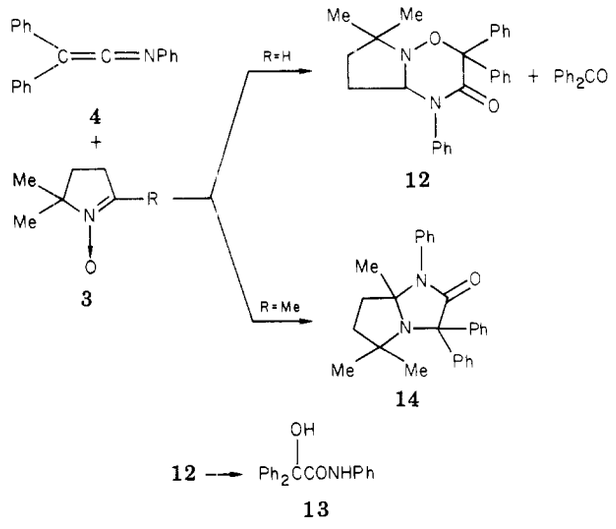
Reaction of the Ketenimine 1 with Cyclic Nitrones 3. When cyclic nitrones such as 1-pyrroline 1-oxides **3** are used in place of benzylideneaniline *N*-oxides **2**, products of a type other than **7** may be formed in the reaction with the ketenimine **1**, because **7** is formed by a reaction sequence which involves attack on the *N*-phenyl group of **2** as shown in Scheme I. Studies on the reactions of ketenimines with cyclic nitrones have not been reported to date.

The ketenimine **1** readily reacted with 5,5-dimethyl-1-pyrroline 1-oxide (**3a**) in benzene at room temperature to give the 1:1 adduct **10a** in quantitative yield. In the reaction of 2,5,5-trimethyl-1-pyrroline 1-oxide (**3b**), however, the ketenimine **1** afforded two 1:1 adducts, **10b** and **11**, in 32 and 34% yields, respectively (Scheme II).

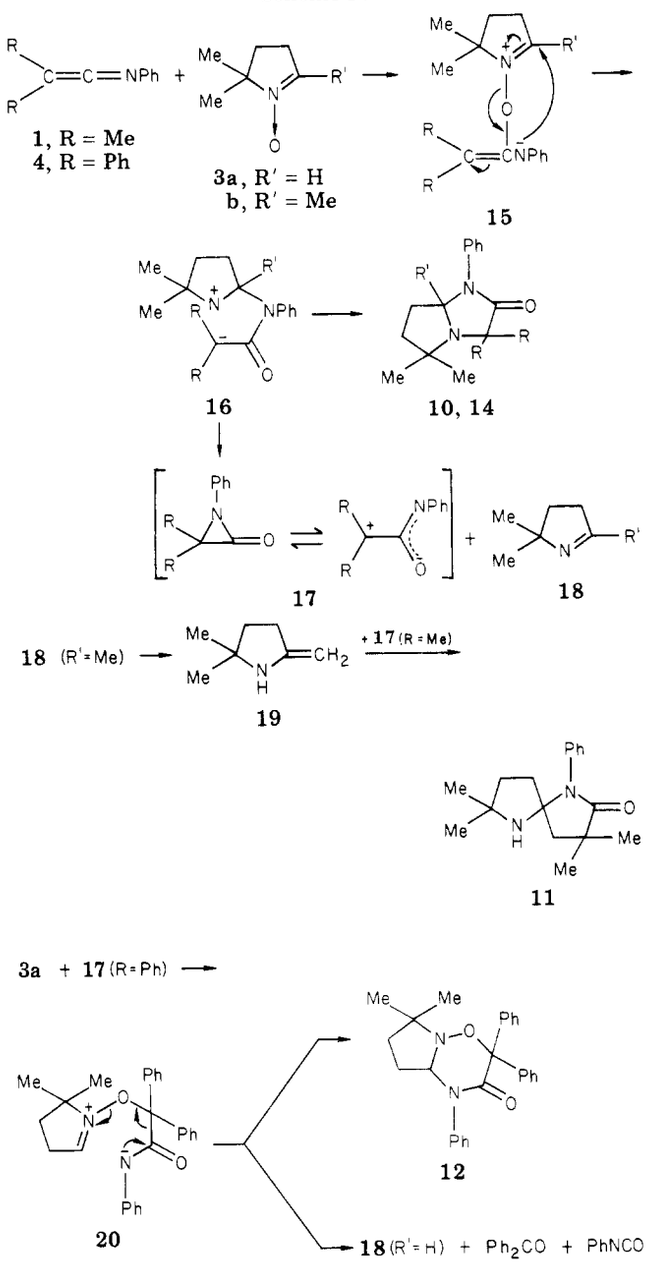
On the basis of their spectral data, both adducts **10a** and **10b** were assigned to be the imidazolidinone derivatives. The adduct **11** exhibited IR absorptions at 3300 (ν NH) and 1670 cm^{-1} (ν C=O), and ^1H NMR signals at δ 0.85, 1.08, 1.30, 1.32 (each s, 3H), and 1.45–2.67 (m, 7 H, $CH_2 \times 3$ + NH, the signal (NH) at δ 1.71 was exchanged with D_2O). From these data, the adduct **11** was deduced to be

(1) O. Tsuge and H. Watanabe, *Heterocycles*, 4, 1905 (1976).
(2) O. Tsuge, H. Watanabe, and K. Masuda, Abstracts, the 36th Spring Meeting of the Chemical Society of Japan, Osaka, April 1977, No. IR 10.
(3) M. W. Barker and J. H. Gardner, *J. Heterocycl. Chem.*, 5, 881 (1968).
(4) N. Murai, M. Komatsu, Y. Ohshiro, and T. Agawa, *J. Org. Chem.*, 42, 448 (1977).
(5) R. N. Pratt, D. P. Stokes, G. A. Taylor, and P. C. Brookes, *J. Chem. Soc. C*, 2086 (1968).

Scheme III



Scheme IV



1-phenyl-3,3,7,7-tetramethyl-1,6-diazaspiro[4.4]nonan-2-one. The reaction pathway will be described below.

Reaction of Diphenylketene-*N*-phenylimine (4) with Cyclic Nitrones 3. As mentioned above, the reaction mode of dimethylketene-*N*-phenylimine (1) with benzylideneaniline *N*-oxides **2** was somewhat different from that of diphenylketene-*N*-phenylimine (**4**). Thus, our attention was next directed toward the reaction of the ketenimine **4** with cyclic nitrones **3**.

When the ketenimine **4** was allowed to react with an equimolar amount of the cyclic nitrone **3a** in benzene at room temperature for 24 h, compound **12**, 7,7-dimethyl-2,2,4-triphenylperhydropyrro[1,2-*b*]-1,2,4-oxadiazin-3-one, whose molecular formula corresponds to that of a compound arising from a 1:2 adduct by the elimination of 5,5-dimethyl-1-pyrroline, and benzophenone were obtained in 36 and 20% yields, respectively, together with unreacted ketenimine **4**. In the same reaction employing 2 mol of the cyclic nitrone **3a**, the yield of **12** increased to 59%. Structural elucidation of **12** was accomplished on the basis of spectral data as well as of the result of acid hydrolysis of **12** which gave diphenylhydroxyacetanilide **13**. In the reaction with the cyclic nitrone **3b**, however, the ketenimine **4** afforded the imidazolidinone derivative **14**.

Reaction Pathway. To explain the formation of imidazolidinone and oxindole derivatives from the reactions of ketenimines with benzylideneaniline *N*-oxides, Ohshiro et al.[4] presumed a 1,2,4-oxadiazolidine intermediate like **9**. As mentioned above, however, cycloadducts such as **9** have never been isolated in the reactions of either ketenes or ketenimines with nitrones, and it is clear that the oxindole **8** is derived from hydrolysis of **7** but not **9**. Recently, Abou-Gharbia and Joullié[6] postulated the mechanistic scheme involving a α-lactone intermediate for the reaction of fluorenylideneamine *N*-oxides with ketenes.

Our results can be simply explained in analogy with known ketene chemistry. The reactions proceed via initial formation of the zwitterion **15**. Subsequent sigmatropic rearrangement of **15** affords the zwitterion **16** capable of undergoing ring closure to imidazolidinone derivatives **10** and **14**. This process is similar to the formation of oxazolidinone derivatives from the reaction of ketenes with nitrones.[6] In some cases, **16** dissociates into a presumed α-lactam intermediate **17** and 1-pyrroline **18**. The former species could exist in equilibrium with a 1,3-dipole. Although trapping of such a lactam has not been accomplished,[7] analogous deoxygenation reactions were observed by Abou-Gharbia and Joullié[6] and by Taylor et al.,[8] who have performed the reactions of ketenes with heteroaromatic *N*-oxides. In addition, Schaumann and Behrens[9] have recently identified several α-thiolactones from the reactions of thioketenes with cyclic nitrones such as **3**. Therefore, it is reasonable to assume the generation of

(6) M. A. Abou-Gharbia and M. M. Joullié, *J. Org. Chem.*, 44, 2961 (1979). We wish to thank Dr. Joullié for her permission to refer to this work.

(7) We found that the ketenimine **4** reacted with the nitrone **2a** to give 1,2,3,5,5-pentaphenylimidazolidin-4-one: mp 207–208 °C; IR 1710 cm^{-1}; ^{13}C NMR δ 75.4 (s), 78.6 (d), 170.8 (s); MS, *m/e* 666 (M^+). Anal. Calcd for $C_{48}H_{38}N_2O_3$: C, 82.85; H, 5.74; N, 4.20. Found: C, 82.90; H, 5.49; N, 4.07.[2] The reaction of **4** with **3a** in the presence of benzylideneaniline gave no products derived from the reaction of benzylideneaniline with α-lactam intermediate **17** (R = Ph), but instead benzylideneaniline was recovered quantitatively. However, this result is not valid as proof that α-lactam intermediate **17** is not present since the pyrroline should be more reactive than benzylideneaniline.

(8) R. N. Pratt, D. P. Stokes, G. A. Taylor, and S. A. Procter, *J. Chem. Soc. C*, 1472 (1971).

(9) E. Schaumann and U. Behrens, *Angew. Chem., Int. Ed. Engl.*, 16, 722 (1977).

α-lactam **17** from the reactions of ketenimines with nitrones.

As depicted in Scheme IV, the formation of **11** and **12** can be readily interpreted by the cycloadditions of **17** (R = Me) to the tautomeric enamine **19** of **18** (R′ = Me) and of **17** (R = Ph) to the nitrone **3a**, respectively. The benzophenone formed from the reaction of **4** with **3a** can also be understood as arising from the decomposition of zwitterion **20**.[10] It has been reported that benzophenone was formed in the reactions of diphenylketene with dimethylaniline *N*-oxide[11] and pyridine *N*-oxide.[12]

Experimental Section

Melting points were determined on a Yanagimoto micromelting point apparatus and were uncorrected. IR, NMR, and mass spectra were obtained on a JASCO IRA-1 spectrometer, Hitachi R-40 and JEOL SX-100 spectrometers, and a Hitachi RMS-4 spectrometer, respectively. IR and NMR spectra were taken in KBr disks and $CDCl_3$ solutions, respectively. Mass spectra were obtained at 70 eV.

Materials. Ketenimines **1** and **4** were prepared from the corresponding amides according to the reported procedures.[13,14] Benzylideneaniline *N*-oxides **2a–d**[15,16] and cinnamylideneaniline *N*-oxide (**2e**)[17] were prepared from the corresponding aldehydes and *N*-phenylhydroxylamine, respectively. Cyclic nitrones **3a** and **3b** were prepared from the reduction of the corresponding γ-nitrocarbonyl compounds according to the reported methods.[18,19]

Reaction of Dimethylketene-*N*-phenylimine (1) with Benzylideneaniline *N*-Oxide (2a). A solution of the ketenimine **1** (0.73 g, 5 mmol) and nitrone **2a** (1.0 g, 5 mmol) in benzene (30 mL) was refluxed, under nitrogen, for 6 h. The solvent was evaporated in vacuo, and the residue was triturated with hexane to give 1.48 g (84%) of the 1:1 adduct **7a**. Recrystallization of **7a** from cyclohexane yielded colorless prisms: mp 101 °C; IR 3400 (NH), 1690 (C=O), 1615 cm^{-1} (C=N); ^1H NMR δ 1.65 (s, 6 H), 6.80–7.92 (m, 15 H), 8.29 (s, 1 H); MS, *m/e* 342 (M^+), 250 (M^+ – PhNH, base peak), 222 (M^+ – PhNHCO). Anal. Calcd for $C_{23}H_{22}N_2O$: C, 80.67; H, 6.48; N, 8.18. Found: C, 80.67; H, 6.49; N, 8.15.

Similarly, the ketenimine **1** reacted with the nitrones **2b–e** in boiling benzene to give the corresponding 1:1 adducts **7b–e**, respectively.

7b: yield 69% (reaction time 4 h); mp 101–102 °C; colorless needles (from cyclohexane); IR 3360 (NH), 1660 (C=O), 1620 cm^{-1} (C=N); ^1H NMR δ 1.66 (s, 6 H), 3.78 (s, 3 H), 6.75–7.84 (m, 14 H), 8.26 (s, 1 H); MS, *m/e* 372 (M^+), 280 (M^+ – PhNH, base peak), 252 (M^+ – PhNHCO). Anal. Calcd for $C_{24}H_{24}N_2O_2$: C, 77.39; H, 6.50; N, 7.52. Found: C, 77.10; H, 6.53; N, 7.55.

7c: yield 77% (reaction time 6 h); mp 178–179 °C; colorless prisms (from MeOH); IR 3360 (NH), 1650 (C=O), 1620 cm^{-1} (C=N); ^1H NMR δ 1.62 (s, 6 H), 6.74–7.82 (m, 14 H), 8.28 (s, 1 H); MS, *m/e* 379, 377 (M^+), 296, 294 (M^+ – PhNH, base peak), 258, 256 (M^+ – PhNHCO). Anal. Calcd for $C_{23}H_{21}N_2OCl$: C, 73.30; H, 5.62; N, 7.43. Found: C, 73.14; H, 5.69; N, 7.44.

7d: yield 82% (reaction time 6 h); mp 148–149 °C; yellow needles (from MeOH); IR 3360 (NH), 1680 (C=O), 1620 cm^{-1} (C=N); ^1H NMR δ 1.64 (s, 6 H), 6.72–8.39 (m, 14 H), 8.40 (s, 1 H); MS, *m/e* 387 (M^+), 295 (M^+ – PhNH, base peak), 267 (M^+ – PhNHCO). Anal. Calcd for $C_{23}H_{21}N_3O_3$: C, 71.30; H, 5.49; N, 10.85. Found: C, 70.73; H, 5.49; N, 10.74.

7e: yield 57% (reaction time 3 h); mp 133–133.5 °C; yellow prisms (from cyclohexane); IR 3400 (NH), 1690 (C=O), 1630 (C=N), 1600 cm^{-1} (C=C); ^1H NMR δ 1.67 (s, 6 H), 6.75–7.65 (m, 17 H, a signal (dd, *J* = 4, 10 Hz) appeared at δ 6.92), 8.09 (broad t, 1 H, *J* = 4 Hz); MS, *m/e* 368 (M^+), 276 (M^+ – PhNH, base peak), 248 (M^+ – PhNHCO). Anal. Calcd for $C_{25}H_{24}N_2O$: C, 81.49; H, 6.57; N, 7.60. Found: C, 81.36; H, 6.58; N, 7.55.

Hydrolysis of 1:1 Adduct 7a. A solution of **7a** (0.2 g) in EtOH (10 mL) was stirred with 2 drops of concentrated HCl at room temperature for 2 h. The mixture was made basic with saturated aqueous $NaHCO_3$ solution and then extracted with $CHCl_3$. The extract was concentrated in vacuo, and the residue was recrystallized from hexane to give 91 mg (96%) of 3,3-dimethyloxindole (**8**), mp 153–154 °C (lit.[4] mp 151–152 °C), as colorless prisms.

Reaction of the Ketenimine 1 with 5,5-Dimethyl-1-pyrroline 1-Oxide (3a). A solution of the ketenimine **1** (0.48 g, 3.34 mmol) and nitrone **3a** (0.38 g, 3.34 mmol) in benzene (20 mL) was stirred, under nitrogen, at room temperature for 12 h. The solvent was evaporated in vacuo to leave a residue, which on trituration with hexane gave 0.86 g (100%) of the imidazolidinone compound **10a**. Recrystallization of **10a** from hexane afforded colorless plates: mp 99–100 °C; IR 1690 cm^{-1} (C=O); ^1H NMR δ 1.18, 1.30, 1.32, 1.60 (each s, 3 H), 1.50–2.48 (m, 4 H), 5.52 (dd, 1 H, *J* = 4, 6 Hz), 6.88–7.52 (m, 5 H); MS, *m/e* 258 (M^+), 244, 243, 138 (M^+ – PhNHCO). Anal. Calcd for $C_{16}H_{22}N_2O$: C, 74.34; H, 8.58; N, 10.84. Found: C, 74.21; H, 8.61; N, 10.81.

Reaction of the Ketenimine 1 with 2,5,5-Trimethyl-1-pyrroline 1-Oxide (3b). A solution of the ketenimine **1** (0.48 g, 3.34 mmol) and nitrone **3b** (0.42 g, 3.34 mmol) in benzene (20 mL) was stirred, under nitrogen, at room temperature for 12 h. The solvent was evaporated in vacuo to leave a residue. The residue was chromatographed on silica gel, using benzene as eluent, giving 0.28 g (31%) of the imidazolidinone compound **10b** and 0.31 g (34%) of the spiro compound **11**.

10b: yellow oil; IR 1700 cm^{-1} (C=O); ^1H NMR δ 1.37–2.71 (m, 19 H, singlets appeared at δ 1.37, 1.40, 1.45, 1.48, and 1.58 respectively), 6.85–7.76 (m, 5 H); MS, *m/e* 272 (M^+), 257, 182, 105, 99. Anal. Calcd for $C_{17}H_{24}N_2O$: C, 74.96; H, 8.88; N, 10.29. Found: C, 75.13; H, 8.75; N, 10.48.

11: mp 105–106 °C; colorless needles (from benzene–hexane); IR 3340 (NH), 1670 cm^{-1} (C=O); ^1H NMR δ 0.85, 1.08, 1.30, 1.32 (each s, 3 H), 1.45–2.67 (m, 7 H, the broad signal at δ 1.71 was exchanged with D_2O), 7.32 (s, 5 H); MS, *m/e* 272 (M^+), 257, 152, 138. Anal. Calcd for $C_{17}H_{24}N_2O$: C, 74.96; H, 8.88; N, 10.29. Found: C, 74.85; H, 8.89; N, 10.36.

Reaction of Diphenylketene-*N*-phenylimine (4) with the Cyclic Nitrone 3a. A solution of the ketenimine **4** (1.0 g, 3.72 mmol) and nitrone **3a** (0.42 g, 3.72 mmol) in benzene (20 mL) was stirred, under nitrogen, at room temperature for 24 h. The mixture was concentrated in vacuo, and the residue was chromatographed (silica gel, benzene) to give 136 mg (20%) of benzophenone and 255 mg (36%) of the perhydrooxadiazinone **12**, along with recovery of **4** (128 mg).

A similar reaction of **4** (1.0 g, 3.72 mmol) with **3a** (0.84 g, 7.35 mmol) afforded 119 mg (17.5%) of benzophenone and 831 mg (59%) of **12**.

12: mp 186–187 °C; colorless prisms (from MeOH); IR 1662 cm^{-1} (C=O); ^1H NMR δ 1.09, 1.32 (each s, 3 H), 1.60–2.40 (m, 4 H), 5.00–5.29 (m, 1 H), 6.92–7.76 (m, 15 H); ^{13}C NMR δ 25.3 (q), 26.3 (q), 29.4 (t), 35.9 (t), 65.1 (s), 80.4 (d), 87.6 (s), 127.2, 127.5, 127.7, 127.9, 129.3, 139.8, 141.4, 141.9, 167.9 (s); MS, *m/e* 398 (M^+), 204 (M^+ – Ph_2C=C=O, base peak), 194, 165, 119. Anal. Calcd for $C_{26}H_{26}N_2O_2$: C, 78.36; H, 6.58; N, 7.03. Found: C, 78.41; H, 6.62; N, 6.93.

Hydrolysis of the Perhydrooxadiazinone 12. A suspension of **12** (0.1 g) in concentrated hydrochloric acid (7 mL) was stirred at 55–60 °C for 14 h. Filtration gave crystals which on recrystallization from MeOH afforded 75 mg (98.6%) of diphenylhydroxyacetanilide (**13**) as colorless needles: mp 175–176 °C; IR 3320, 1660 cm^{-1}; ^1H NMR δ 6.85–7.68 (m, 15 H), 8.50 (broad, 2 H); MS, *m/e* 303 (M^+), 183 (M^+ – PhNHCO, base peak). Anal. Calcd for $C_{20}H_{17}NO_2$: C, 79.18; H, 5.65; N, 4.62. Found: C, 79.43; H, 5.66; N, 4.62.

Reaction of the Ketenimine 4 with the Cyclic Nitrone 3b. After a solution of the ketenimine **4** (1.0 g, 3.72 mmol) and nitrone **3b** (0.48 g, 3.72 mmol) in benzene (20 mL) was stirred, under

(10) Benzophenone did not arise from the decomposition of **12**, because **12** was unchanged on heating in benzene for 12 h.

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nitrogen, at room temperature for 24 h, the mixture was treated according to the same procedure as in the case of **3a** to give 387 mg (26%) of the imidazolidinone compound **14** as colorless prisms (from cyclohexane): mp 209–210 °C; IR 1695 cm^{-1}; ^1H NMR δ 0.51, 1.19, 1.30 (each s, 3 H), 1.64–2.52 (m, 4 H), 6.91–8.26 (m, 15 H); ^{13}C NMR δ 27.0 (q), 28.4 (q), 31.6 (q), 37.5 (t), 43.1 (t), 63.6 (s), 73.4 (s), 87.1 (s), 126.8, 126.9, 127.3, 127.5, 128.2, 129.1, 132.7, 137.2, 140.3, 145.7, 175.1 (s); MS, *m/e* 396 (M^+). Anal. Calcd for $C_{27}H_{28}N_2O$: C, 81.78; H, 7.12; N, 7.07. Found: C, 81.59; H, 7.06; N, 7.06.

Registry No. 1, 14016-34-3; **2a**, 1137-96-8; **2b**, 3585-93-1; **2c**, 5909-74-0; **2d**, 3585-90-8; **2e**, 37056-75-0; **3a**, 3317-61-1; **3b**, 3146-84-7; **4**, 14181-84-1; **7a**, 71871-80-2; **7b**, 71871-81-3; **7c**, 71871-82-4; **7d**, 71871-83-5; **7e**, 71871-84-6; **8**, 19155-24-9; **10a**, 71871-85-7; **10b**, 71871-86-8; 11, 71871-87-9; **12**, 71871-88-0; **13**, 5554-37-0; **14**, 71871-89-1; benzophenone, 119-61-9; 1,2,3,5,5-pentaphenylimidazolidin-4-one, 71871-90-4.

Nucleosides. 112. Synthesis of Some New Pyrazolo[1,5-*a*]-1,3,5-triazines and Their *C*-Nucleosides[1,2]

Steve Y.-K. Tam, Robert S. Klein,* Iris Wempen, and Jack J. Fox

Laboratory of Organic Chemistry, Memorial Sloan-Kettering Cancer Center, Sloan-Kettering Institute, Sloan-Kettering Division of the Graduate School of Medical Sciences, Cornell University, New York, New York 10021

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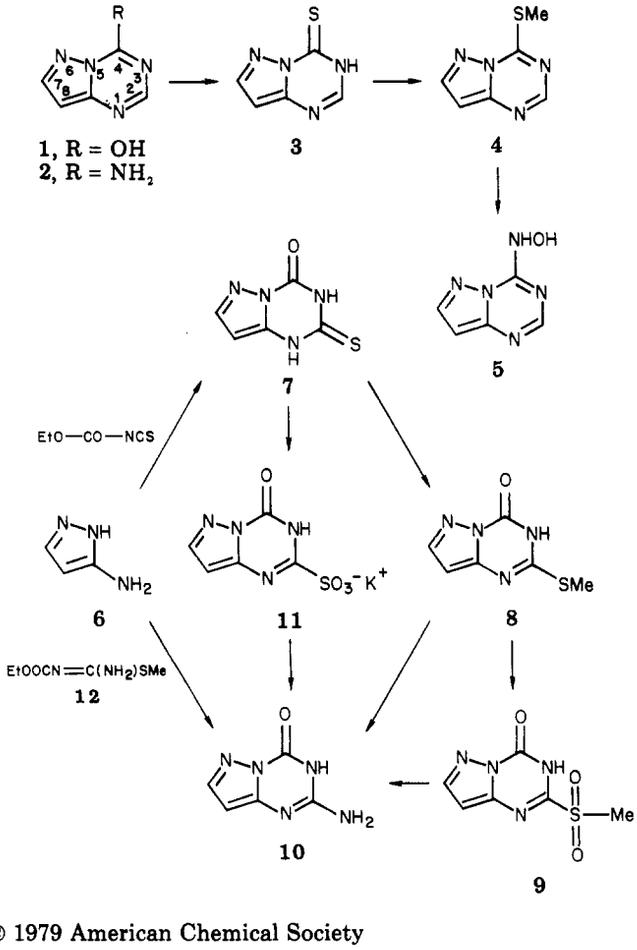
The synthesis of the new C-7 ribosylated pyrazolo[1,5-*a*]-1,3,5-triazine *C*-nucleosides **18**, **19**, and **20** is described. A key step in the conversion **17** → **18** → **19** → **20** involves direct substitution of the 4-amino group of unblocked aminopyrazolotriazine riboside **17** (APTR) with H_2S. The β configuration at C-1′ is retained throughout this sequence. Synthesis of the corresponding and as yet unknown pyrazolotriazine bases **3**, **4**, and **5** is also described.

As part of our program concerned with the synthesis and biological testing of *C*-nucleoside analogues of the natural purine nucleosides, we reported recently the synthesis of 4-amino-8-(β-D-ribofuranosyl)pyrazolo[1,5-*a*]-1,3,5-triazine (**17**, APTR) (see Scheme II) and of 4-oxo-3*H*-8-(β-D-ribofuranosyl)pyrazolo[1,5-*a*]-1,3,5-triazine (OPTR).[3] These are isosteres of adenosine and inosine, respectively. Preliminary in vitro and in vivo testings[2,4,5] have shown that these compounds possess antileukemic activities which are significantly better than those of the corresponding formycins[6,7] with which they are also isosteric.

We have now extended our investigation of the APTR class of *C*-nucleosides and wish to report here synthetic studies which have led to the 4-thioxo, 4-methylthio, and 4-hydroxylamino derivatives **18**, **19**, and **20** (Scheme III). Such derivatives are of potential biomedical interest in view of the known anticancer activity of the nucleosides of 6-mercaptopurine and its methylthio derivative and of

Scheme I



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