Table I

chelate, mg	solvent	time, h	product amt, mg	product % yield
114	CHCN	3.5	8	13
170	C_6H_6	1	12	13
220	CH_2Cl_2	3.5		0
113	THF	8.5	17	28

tography (silica gel, 1000 μm, 20% EtOAc/$CHCl_3$, R_f 0.5; see Table I).

Reaction of BDU with Chelate 10. A solution of chelate **10** (0.237 g, 0.74 mmol) in 10 mL of CH_3CN was treated with DBU (107 mg, 0.70 mmol) and heated at 67 °C for 45 h. Concentration of the solution left a dark red oil which was chromatographed on 40 g neutral activity IV alumina. Ether elution yielded the product as a red solid: 77 mg (0.24 mmol, 32%); IR (CH_2Cl_2) 1908 (M–CO), 1608 (M–acyl), 1730 cm^{-1} (ester); NMR ($CDCl_3$) δ 4.95 (br m, 1 H, NH), 4.46 (s, 5 H, Cp), 3.95 (br m, 1 H, CH–CO_2), 3.84 (s, 3 H, OCH_3), 3.18 (br m, 1 H, N–CH), 2.5–1.8 (br m, 6 H, CH_2).

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Registry No. **4**, 84027-50-9; **5**, 84027-51-0; **6-c**, 84027-52-1; **6-t**, 84049-22-9; **7**, 84027-53-2; **10**, 84027-54-3; **11a**, 84011-99-4; **11b**, 84012-00-0; Fp(η^2-isobutene)PF_6, 84027-56-5; methyl pyruvate dimethyl ketal, 10076-48-9; allyl alcohol, 107-18-6; methyl 2-oxo-5-hexenoate, 84012-01-1; allyl 2-oxo-5-hexenoate, 84012-02-2; 1,3-dithiane, 505-23-7; 4-bromo-1-butene, 5162-44-7; methyl chloroformate, 79-22-1; methyl 2-(3-buten-1-yl)-1,3-dithiane-2-carboxylate, 84012-03-3; allylacetic acid, 591-80-0; ethyl 4-pentenoate, 1968-40-7; diethyl oxalate, 95-92-1; 2-oxo-5-hexenoic acid, 80003-58-3; diethyl 2-allyl-3-oxobutanedioate, 56716-05-3; ammonia, 7664-41-7.

Interaction of 3,4-Dinitro-1-methylpyrrole with Secondary Amines: Alternative Formation of Pyrrolines or Cine Substitution Products

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The course of the reaction of 1-methyl-3,4-dinitropyrrole with piperidine or morpholine in acetonitrile depends upon the reaction conditions. At refluxing temperature the main products are the cine substitution products, whereas at room temperature 2-pyrrolines are formed. Base-promoted decomposition of the latter yields products of formal direct denitration, whereas in the presence of Me_3NH^+ ion cine substitution products are obtained.

In connection with our studies concerning the reactions of nitro pyrroles with nucleophiles,[1] we recently reported that a cine substitution reaction occurs when 1-methyl-3,4-dinitropyrrole (**1**, Chart I) reacts with piperidine in refluxing acetonitrile to yield 1-methyl-4-nitro-2-piperidinopyrrole (**2a**) as the main product. A minor amount of a ring-opening product, 2,3-dinitro-1,4-dipiperidinobuta-1,3-diene (**3a**), was also obtained.

We have now found that the course of the reaction of **1** with secondary aliphatic amines may be sensibly affected by the initial reactant ratio and by the temperature.

The reactions of **1** with piperidine and the less nucleophilic morpholine in acetonitrile, either at room temperature or at reflux temperature, are here described, together with some reactions involving one of the possible primary reaction products.

Results

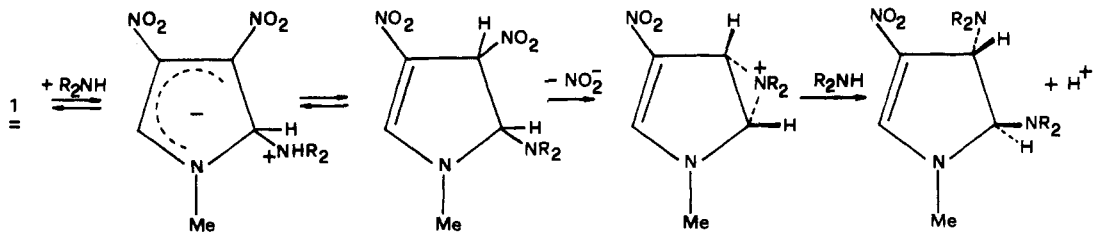
(A) Reaction of 1 with Piperidine. At Room Temperature with a Tenfold Excess of Piperidine. Under these conditions pyrroline **4a** is the only product. It was characterized by ^1H NMR and CI mass spectroscopy, which showed an intense $(M + 1)^+$ peak. Pyrroline **4a**, like other related compounds such as 4,5-bis(dialkylamino)-4,5-dihydroimidazoles,[2] shows a very weak molecular peak in EI mass spectroscopy. A nitro enamine structure, similar to that of pyrroline **4c**, as formed from **1** and MeO^-,[3] is supported by the UV spectrum of **4a**. The low coupling constant between protons at positions 4 and 5 suggests a trans structure, similar to that of **4c** and 1-substituted *trans*-4,5-dimorpholino-4,5-dihydroimidazoles.[2] The stereochemical course of the formation of pyrrolines is similar to that of the formation of 2,5-dimethyl-*trans*-2,3-bis(dialkylamino)-4-nitro-2,3-dihydrothiophenes (**5**), whose structures were established by X-ray crystallography.[4] Both courses indeed lead to compounds bearing two trans amino groups at position α and β. Although this stereoselective behavior may be due to thermodynamic control, trans isomers being generally more stable, the formation of the trans isomer could also occur under kinetic control. As shown in Scheme I, nucleophilic attack at the α position could be followed by protonation of the adjacent β position, intramolecular nucleophilic displacement of the β nitro group by the neighboring α R_2N group, and the eventual attack of another R_2NH molecule at the ensuing bicyclic cation.[18] Nitro groups have been indeed shown to be good leaving groups in aliphatic substitution and elimination reactions.[5,6]

The reaction of pyrroline formation is not so straightforward as suggested by the formation of one product only. At least one other product is formed together with **4a** at the beginning of the reaction but eventually disappears, as shown by ^1H NMR and TLC measurements. The disappearance of the signal of **1** at δ 7.5 is accompanied by the appearance of the signals of pyrroline **4a** at δ 7.9

(1) Mencarelli, P.; Stegel, F. *J. Chem. Soc., Chem. Commun.* **1980**, 123 and references therein cited.
(2) Citerio, L.; Rivera, E.; Saccarello, M. L.; Stradi, R.; Gioia, B. *J. Heterocycl. Chem.* **1980**, *17*, 97.
(3) Mencarelli, P.; Stegel, F. *J. Chem. Soc., Chem. Commun.* **1978**, 564.
(4) Mugnoli, A.; Dell'Erba, C.; Guanti, G.; Novi, M. *J. Chem. Soc., Perkin Trans. 2* **1980**, 1764.
(5) Benn, M.; Meesters, A. C. M. *J. Chem. Soc., Chem. Commun.* **1977**, 597.
(6) Gray, P. G.; Norris, R. K.; Wright, T. A. *J. Chem. Soc., Chem. Commun.* **1979**, 259.

0022-3263/83/1948-0162$01.50/0

Scheme I



Scheme II

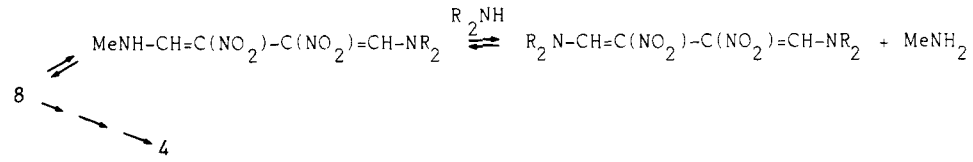
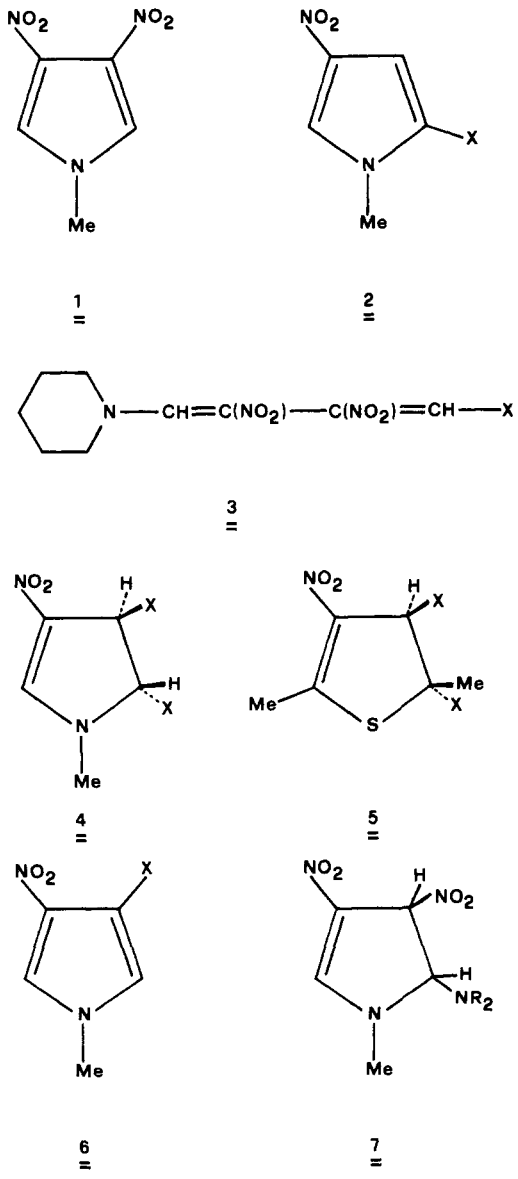
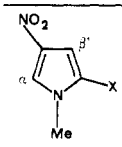


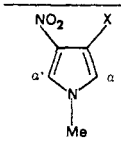
Chart I



[a] a, X = piperidino; b, X = morpholino; c, X = OMe; d, X = NHMe.

Table I. UV and Ring-Proton ^{1}H NMR Data for Methoxy- and (Dialkylamino)nitro-1-methylpyrroles

compd	X	λ_{max},[a] nm (log ϵ)	δ_α	$\delta_{\beta'}$	$J_{\alpha\beta'}$, Hz
	OMe[b,c]	280 (3.8), 359 (3.6)	6.95	5.68	2.4
	piperidino[c,d]	281 (3.9), 358 (3.6)	7.12	6.00	2.25
	morpholino[e]	280 (3.8), 348 (3.6)	7.19	6.10	2.2

compd	X	λ_{max},[a] nm (log ϵ)	δ_α	$\delta_{\alpha'}$	$J_{\alpha\alpha'}$, Hz
	OMe[b,e]	297 (4.0)	6.16	7.32	3.0
	piperidino[e]	310 (3.9)	6.08	7.36	3.0
	morpholino[e]	308 (3.9)	6.14	7.46	3.0

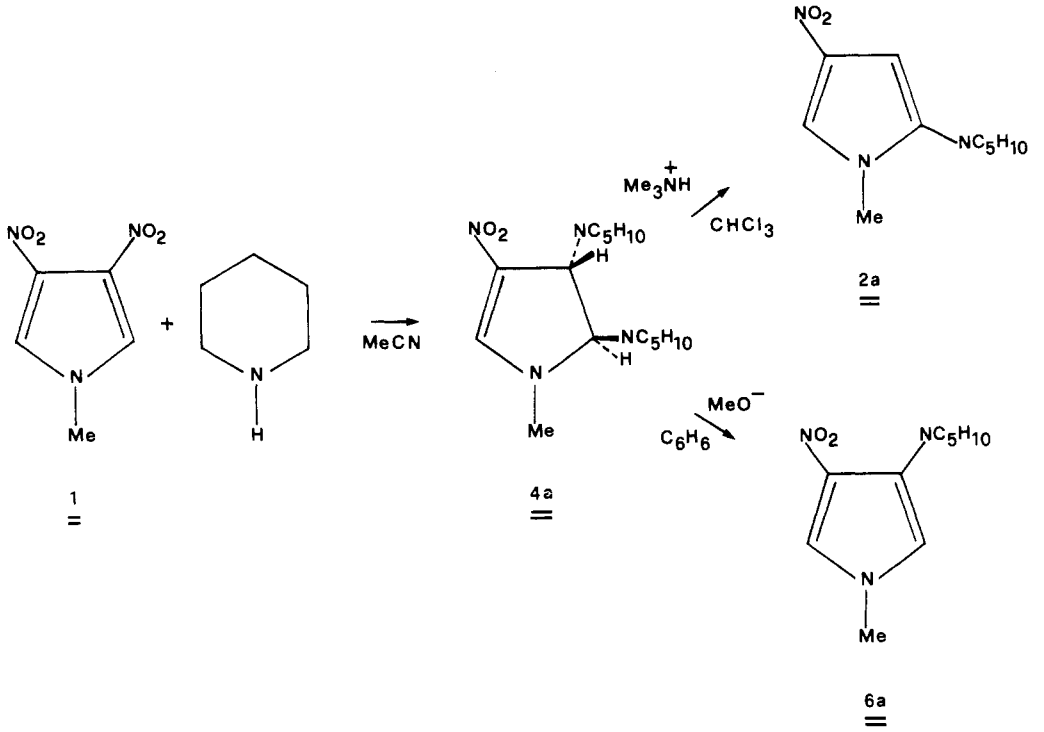
[a] In MeOH. [b] Reference 8. [c] ^{1}H NMR spectra in CCl_4. [d] Reference 1. [e] ^{1}H NMR spectra in $CDCl_3$.

and 4.1–4.3 and two further weak singlets at δ 8.4. With time these signals disappear, and only those of the pyrroline are observed. Scheme II shows a possible pattern for the reversible formation of two ring-opening reaction products, **3a** being the product of a nitro-activated nucleophilic vinylic substitution on **3d**.[7] We have verified the reversibility of the ring-opening reaction by allowing **3a** to react with piperidine and methylamine at room temperature. Under these conditions **3a** disappears rapidly and is replaced by pyrrole **1** and pyrroline **4a**. Within 30 min only the signals of the pyrroline are detectable, the dinitropyrrole having been converted into the pyrroline.

In Refluxing Acetonitrile with 2 Equiv of Piperidine. The cine substitution product **2a** is the main product under these reaction conditions (86%).[1] It is formed together with a minor amount of the ring-opening product **3a** and of *N*-nitrosopiperidine. Structural assignments for the cine substitution product and for other products of formal substitution of **1** had to be made by comparison of both ^{1}H NMR and UV spectroscopic data with those of the related methoxy- and nitro-substituted 1-methylpyrroles, whose structures had previously been

(7) Marchetti, L.; Passalacqua, V. *Ann. Chim. (Rome)* **1967**, *57*, 1266. Fetell, A. I.; Feuer, H. *J. Org. Chem.* **1978**, *43*, 1238.

Scheme III



established by nuclear Overhauser effect (Table I).[3,8] Hydrogen coupling constants reported for pyrroles without nitro groups are indeed of little help in assigning structures of substituted nitro pyrroles. Typical coupling constants (in hertz) for nitro or dinitro pyrroles[3,8,9] are here compared with mean values (in parentheses), as reported in a recent review:[10] $J_{3,4}$ = 4.0–4.4 (3.4–3.8); $J_{2,3}$ = 3.4 (2.4–3.1); $J_{2,5}$ = 3.0 (1.95–2.3); $J_{2,4}$ = 2.1–2.4 (1.35–1.8). In the presence of nitro groups, coupling constants generally increase, but the relative coupling constant sequence is not modified.

In Refluxing Acetonitrile with a Tenfold Excess of Piperidine. Under these reaction conditions the reaction occurs more rapidly (2 h) than with 2 equiv of piperidine. The yield of cine substitution product decreases to 35%, whereas the ring-opening reaction becomes more important (10%), and the reaction of formation of the *N*-nitrosamine disappears. At variance with the reaction carried out with 2 equiv of amine, now also 1-methyl-3-nitro-4,5-dipiperidino-2-pyrroline (**4a**) is formed (40%). It was verified that under these reaction conditions compound **2a** does not yield pyrroline **4a**.

(B) Reaction of 1 with Morpholine. The main reaction paths for this reaction are essentially the same as those described with piperidine. At room temperature, with a tenfold excess of morpholine, only pyrroline **4b** is obtained. The reaction course is again characterized by the initial formation of ring-opening products that slowly disappear. However, morpholine yields a smaller amount of ring-opening products than does piperidine. Even in refluxing acetonitrile the amounts were too small to permit isolation, and evidence for their presence was derived from TLC and ^{1}H NMR spectra. In refluxing acetonitrile, with 3 equiv of morpholine a cine substitution reaction occurs. Owing to the lower nucleophilicity of morpholine, longer reaction times were required than with piperidine. In refluxing acetonitrile with a tenfold excess of morpholine the yield of the cine substitution product (**2b**) decreases from 90% to 85%; at the same time the ring-opening products, that are not detectable in the reaction with 3 equiv of amine, become detectable (2%), and also pyrroline **4b** is formed appreciably (13%).

Acid- and Base-Promoted Elimination of One Molecule of Amine from Bis(dialkylamino)pyrrolines. Bis(dialkylamino)pyrrolines **4a** and **4b** undergo elimination of one molecule of amine in the presence of trimethylammonium ion in $CHCl_3$ to yield 2-(dialkylamino)-1-methyl-4-nitropyrroles (**2**), the products of formal cine substitution reaction of **1** (Scheme III). The elimination of morpholine from **4b** is more rapid than the elimination of piperidine from **4a**, because of the better leaving group ability of morpholine.

On the other hand, with sodium methoxide in benzene under heterogeneous conditions, pyrrolines **4a** and **4b** undergo elimination of amine to yield 3-(dialkylamino)-1-methyl-4-nitropyrroles **6a** and **6b** (Scheme III), according to a pattern similar to that observed in the base-promoted elimination of MeOH from pyrroline **4c**.[8]

Final Remarks. Depending upon the reaction conditions, pyrrole **1** reacts with piperidine or morpholine in MeCN to yield either 2-pyrrolines **4** or cine substitution products **2**. In contrast, **1** was shown to react with MeO^- in MeOH to yield pyrroline **4c** only. The cine substitution of **1** with secondary amines resembles those of 2,3-dinitronaphthalene[11] and 6,7-dinitroquinoxaline.[12] 3,4-Dinitrothiophene, a compound related to **1**, reacts with secondary amines in methanol to yield ring-opening compounds[13] such as **3**, whereas 2,5-dimethyl-3,4-dinitrothiophene reacts with neat piperidine or morpholine to yield dihydrothiophenes **5**.[4] 3,4-Dinitrothiophene undergoes also the cine substitution reaction (e.g., with

(8) Bonaccina, L.; Mencarelli, P.; Stegel, F. *J. Org. Chem.* **1979**, *44*, 4420.
(9) Grehn, L. *Chem. Scr.* **1978**, *13*, 67.
(10) Jones, R. A.; Bean, G. P. "The Chemistry of Pyrroles"; Academic Press: London, 1977.
(11) Guanti, G.; Thea, S.; Dell'Erba, C. *Tetrahedron Lett.* **1976**, 461.
(12) Nasielski-Hinkens, R.; Pauwels, D.; Nasielski, J. *Tetrahedron Lett.* **1978**, 2125.
(13) Dell'Erba, C.; Spinelli, D.; Leandri, G. *J. Chem. Soc., Chem. Commun.* **1969**, 549.

thiolate ions), but this reaction is complicated by the formation of di- and tetrahydrothiophene derivatives.[14]

Pyrrolines can aromatize to pyrroles upon loss of either a molecule of amine, as mentioned above, or of H_2, thus displaying behavior similar to that of 1-acyl-4,5-bis(dialkylamino)-4,5-dihydroimidazoles.[2,15] Rearomatization upon loss of H_2 or of a molecule of amine compete in the reaction of the morpholinopyrroline **4b** with chloranil, since tetrachlorohydroquinone, as the product of reduction of chloranil, is an acid strong enough to promote the amine elimination reaction. A similar behavior is not displayed by the piperidino pyrroline **4a** because piperidine is a worse leaving group than morpholine.

Finally, it seems worth asking whether pyrrolines are intermediates in the formation of cine substitution products when the reaction is carried out in refluxing MeCN. Such a reaction could involve a certain amount of the conjugate acid of the amine, formed according to Scheme I. Despite the observed tendency of pyrrolines to undergo the acid-promoted elimination, we found that pyrroline **4a**, as obtained from **1** and a tenfold excess of piperidine at room temperature, when subjected in the same reaction mixture to those reaction conditions that favor the formation of the cine substitution product (refluxing in MeCN), was converted into the cine substitution product in a small yield (5%).

Therefore, it appears that in the reaction of **1** with amines the formation of the cine substitution product does not necessarily require the formation of a bis(dialkylamino)pyrroline as an intermediate.

Experimental Section

Melting points are uncorrected. UV–visible spectra were recorded on a Cary 219 instrument. Electron impact (EI) mass spectra were obtained on an AEI MS12 spectrometer; chemical ionization (CI) mass spectra were obtained with CH_4 on a 5982A Hewlett-Packard instrument provided with a 5934A Hewlett-Packard data system; high-resolution mass spectra were obtained with a VG 7070F instrument. ^1H NMR spectra were obtained with a JEOL C60-HL apparatus. Relevant UV and ^1H NMR data are collected in Table I, together with similar data for 1-methyl-4-nitro methoxypyrroles. Elemental analyses were carried out at the Microanalytical Laboratory of the Chemistry Institute of the University of Trieste.

1-Methyl-3,4-dinitropyrrole (**1**) was prepared according to a described procedure.[16]

1-Methyl-3-nitro-*trans*-4,5-dipiperidino-2-pyrroline (4a) was prepared by allowing **1** (0.25 g) to react with 10 equiv of piperidine in 60 mL of acetonitrile at room temperature (ca. 20 °C) until disappearance of **1** (15–20 h) as followed by TLC (silica gel; benzene/ethyl acetate, 1:1). The solvent was removed at low pressure at a temperature lower than 30 °C. The final residue was rapidly eluted with ethyl acetate under a slight N_2 pressure through a silica gel column in order to remove tars. The greasy residue was taken up in a few milliliters of ethyl ether, which induced the crystallization of a yellow product. Recrystallization from ethyl ether–acetone gave **4a** (365 mg, 85%) as a pale yellow solid: mp 114.5–115.5 °C dec; ^1H NMR (acetone-d_6) δ 1.5 (m, 12 H, $NCH_2CH_2CH_2$), 2.5(m, 8 H, NCH_2), 3.18 (s, 3 H, NCH_3), 4.17 (d, 1 H, J = 3 Hz), 4.34 (d, 1 H, J = 3 Hz), 8.06 (s, 1 H, alkenic H); UV (MeOH) λ_{max} 230 nm (log ϵ 3.7), 376 (4.3); CI mass spectrum, m/e 295 $(M + 1)^+$.

1-Methyl-4-nitro-2-piperidinopyrrole (2a). (A) Upon Reaction of 1 and Piperidine in Refluxing Acetonitrile.[1] Compound **1** (0.25 g) was refluxed in 60 mL of acetonitrile with 2 equiv of piperidine, until TLC analysis (silica gel, ethyl acetate) showed no appreciable change of the concentration of **1** (30 h). At this stage TLC and ^1H NMR analysis showed the presence of three reaction products besides some unreacted **1**. Acetonitrile was removed at reduced pressure at a temperature lower than 30 °C. The residue was separated into its components by chromatography on a silica gel column with benzene–ethyl acetate. Compound **2a** was the first one to be eluted (yield 86%). The following compounds were then eluted in the following order: *N*-nitrosopiperidine (identified by comparison of the ^1H NMR spectrum with literature data),[17] compound **1** (10%), and 2,3-dinitro-1,4-dipiperidinobuta-1,3-diene: mp 201–203 °C (lit.[13] mp 200 °C); ^1H NMR ($CDCl_3$) δ 1.7 (m, 12 H), 3.5 (m, 8 H), 8.4 (s, 2 H); yield 4%.

(B) Acid-Promoted Elimination of Piperidine from Pyrroline 4a. Pyrroline **4a** (0.48 g) was refluxed in 10 mL of anhydrous chloroform with 0.3 g of trimethylammonium chloride under magnetic stirring.[2] The reaction was followed by TLC until **4a** disappeared completely (1 h). After evaporation of the solvent, the residue was repeatedly extracted with ethyl acetate. The residue after removal of the ethyl acetate was found (^1H NMR) to be mainly **2a** (80 mg, 23%), together with a lower amount of an unidentified reaction product. The isomeric 1-methyl-3-nitro-4-piperidinopyrrole was not detected.

1-Methyl-*trans*-4,5-dimorpholino-3-nitro-2-pyrroline (4b) was prepared in a way similar to that described for dipiperidinopyrroline **4a** by allowing **1** (0.25 g) to react 3 days at room temperature with 10 equiv of morpholine in acetonitrile. The chromatographic treatment was more complicated, since the crude reaction product is completely soluble in polar solvents only, so that the application of the crude reaction mixture to the silica gel column was made in acetonitrile, whereas elution was made with ethyl acetate and eventually acetonitrile. Crystallization of the solid residue from petroleum ether (bp 40–70 °C) gave **4b** as a yellow solid: 380 mg (87%); mp 140–141.5 °C dec; ^1H NMR (acetone-d_6) δ 2.6 (m, 8 H, NCH_2CH_2O), 3.20 (s, 3 H, NCH_3), 3.6 (m, 8 H, NCH_2CH_2O), 4.20 (d, 1 H, J = 3 Hz), 4.46 (d, 1 H, J = 3 Hz), 8.09 (s, 1 H, alkenic H); UV (MeOH) λ_{max} 230 nm (log ϵ 3.7), 375 (4.3); CI mass spectrum, m/e 299 $(M + 1)^+$. Anal. Calcd for $C_{13}H_{22}N_4O_4$: C, 52.33; H, 7.43; N, 18.78. Found: C, 52.27; H, 7.58; N, 18.82.

1-Methyl-2-morpholino-4-nitropyrrole (2b). (A) Upon Reaction of 1 with Morpholine in Refluxing Acetonitrile. The substrate was allowed to react 70 h with a threefold excess of morpholine in refluxing acetonitrile. After removal of the solvent and chromatography, compound **2b** was isolated as a yellow solid: yield 90%; mp 130.5–131 °C (CCl_4); ^1H NMR ($CDCl_3$) δ 2.8 (m, 4 H, NCH_2CH_2O), 3.46 (s, 3 H, NCH_3), 3.7(m, 4 H, NCH_2CH_2O), 6.10 (d, 1 H, J = 2.2 Hz), 7.19 (d, 1 H, J = 2.2 Hz); UV λ_{max} (see Table I); mass spectrum, calcd for $C_9H_{13}N_3O_3$ (M^+) m/e 211.0957, found 211.0950.

(B) Acid-Promoted Elimination of Morpholine from Pyrroline 4b. Pyrroline **4b** (0.47 g) was refluxed 8 h in 10 mL of chloroform together with 0.31 g of trimethylammonium chloride. After removal of the solvent, the residue was extracted several times with ethyl acetate, and the solvent was removed from the extracts. The residue was purified by chromatography upon silica gel, starting with a benzene–ethyl acetate mixture containing 10% of the latter and gradually increasing the ester concentration. The first compound to be eluted was **2b** (140 mg, 53%). Nearly 20% of the starting pyrroline was recovered. Traces of other compounds were also eluted but were not identified.

Dehydrogenation of 4a with Chloranil. A solution of the pyrroline in benzene (0.37 g in 15 mL) was dropped into a refluxing solution of 0.31 g of chloranil in 15 mL of benzene, and the resulting solution was refluxed 40 h.[15] Some solid compound was removed by decantation, and the solvent was removed under reduced pressure. The residue was purified by chromatography on silica gel with benzene. Only one product was isolated: 170

(14) Dell'Erba, C.; Spinelli, D.; Leandri, G. *Gazz. Chim. Ital.* **1969**, *99*, 535. Novi, M.; Guanti, G.; Sancassan, F.; Dell'Erba, C. *J. Chem. Soc., Perkin Trans. 1* **1978**, 1141.

(15) Citerio, L.; Saccarello, M. L.; Stradi, R.; Gioia, B. *J. Chem. Res., Miniprint* **1979**, 4001.

(16) Novikov, S. S.; Belikov, V. M. *Izv. Akad. Nauk SSSR, Ser. Khim.* **1959**, 1098.

(17) Simons, W. W., Ed. "The Sadtler Handbook of Proton NMR Spectra"; Sadtler: Philadelphia, 1978; p 437.

(18) **Note Added in Proof**: A similar bicyclic cation seems to be involved in the intramolecular acid-promoted interconversion between 2-pyrrolyl and 3-pyrrolyl sulfides (DeSales, J.; Greenhouse, R.; Muchowski, J. M. *J. Org. Chem.* **1982**, *47*, 3668).

mg (46%); yellow solid; mp 194.5–195 °C (acetone–petroleum ether); ^{1}H NMR (acetone-d_6) δ 1.6 (m, 12 H, $NCH_2CH_2CH_2$), 3.1 (m, 8 H, $NCH_2CH_2CH_2$), 3.53 (s, 3 H, NCH_3), 7.50 (s, 1 H); EI mass spectrum, m/e 292 (M^+); UV (CH_3CN) λ_{max} 225, 294 nm. Anal. Calcd for $C_{15}H_{24}N_4O_2$: C, 61.62; H, 8.27; N, 19.16. Found: C, 61.9; H, 8.30; N, 19.2. Spectroscopic data agree with the formation of 1-methyl-3-nitro-4,5-dipiperidinopyrrole.

Dehydrogenation of 4b with Chloranil. The procedure involved the use of a pyrroline **4b** suspension in benzene but was otherwise similar to that above described. A shorter time was required (15 h). Two main reaction products were separated after chromatography: the first one to be eluted was 1-methyl-2-morpholino-4-nitropyrrole (yield 37%); the other product was a dimorpholinonitro-1-methylpyrrole, presumably 1-methyl-2,3-dimorpholino-4-nitropyrrole: yield 8%; mp 247–249 °C dec [petroleum ether (bp 40–70 °C)–chloroform]; ^{1}H NMR ($CDCl_3$) δ 3.1 (m, 8 H, NCH_2CH_2O), 3.49 (s, 3 H, NCH_3), 3.8 (m, 8 H, NCH_2CH_2O), 7.29 (s, 1 H); EI mass spectrum, 296 m/e (M^+); UV (CH_3CN) λ_{max} 224, 290 nm. Also a minor amount of an unidentified blue compound, presumably formed upon interaction between chloranil and morpholine, was isolated.

1-Methyl-3-nitro-4-piperidinopyrrole (6a). Pyrroline **4a** (0.4 g) was dissolved in 50 mL of benzene and refluxed 8 h with an equivalent amount of sodium methoxide (2.6 M in MeOH). After removal of the solvent and inorganic products, the residue was purified by chromatography on a silica gel column, with benzene/1:1 benzene–ethyl acetate, to give a red oil. This was crystallized from hexane to give **6a**: 100 mg (35%); orange solid; mp 69.5–70 °C; ^{1}H NMR ($CDCl_3$) δ 1.7 (m, 6 H, $NCH_2CH_2CH_2$), 2.9 (m, 4 H, $NCH_2CH_2CH_2$), 3.59 (s, 3 H, NCH_3), 6.08 (d, 1 H, J = 3 Hz), 7.36 (d, 1 H, J = 3 Hz); UV λ_{max} (see Table I); mass spectrum, calcd for $C_{10}H_{15}N_3O_2$ (M^+) m/e 209.1164, found 209.1152.

1-Methyl-3-morpholino-4-nitropyrrole (6b). A solution of pyrroline **4b** (80 mg) in 15 mL of benzene was refluxed 10 h with an equivalent amount of sodium methoxide (2.6 M in MeOH). The reaction mixture was filtrated from salts, benzene was removed from the solution. The residue was purified by chromatography upon silica gel with ethyl acetate, and crystallized from CCl_4, to give **6b** (27 mg, 47%) as an orange solid: mp 114.5–115 °C (CCl_4); ^{1}H NMR ($CDCl_3$) δ 3.0 (m, 4 H, NCH_2CH_2O), 3.64 (s, 3 H, NCH_3), 3.9 (m, 4 H, NCH_2CH_2O), 6.14 (d, 1 H, J = 3 Hz), 7.46 (d, 1 H, J = 3 Hz); mass spectrum, calcd for $C_9H_{13}N_3O_3$ (M^+) m/e 211.0957, found 211.0956; UV λ_{max} (see Table I).

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Registry No. 1, 68712-54-9; **2a**, 74460-26-7; **2b**, 83831-96-3; **3a**, 19985-38-7; **4a**, 83831-97-4; **4b**, 83831-98-5; **6a**, 83831-99-6; **6b**, 83832-00-2; piperidine, 110-89-4; methylamine, 74-89-5; morpholine, 110-91-8; 1-methyl-3-nitro-4,5-dipiperidinopyrrole, 83832-01-3.

Addition Reaction of Thebaine and Related Compounds with Acetylenic Dienophiles: The Structure–Reactivity Relationship

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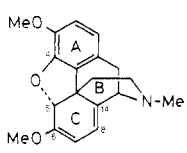
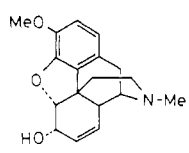
The addition reaction of thebaine (1) with methyl propiolate (MP) and dimethyl acetylenedicarboxylate (DMAD) has been shown to give different products depending on the solvent used. While the Diels–Alder adducts **3** and **4** were the only products obtained in benzene, the reaction with MP in acetonitrile gave the novel 1:1 adduct **8**, and that with DMAD in methanol afforded the methanol-added product **11**, both in high yields. These novel products were derived from the initial C(9)–N bond scission of 1. 6-Demethoxythebaine (**17**) gave only the Diels–Alder adduct **18**. β-Dihydrothebaine acetate (**21**) gave no Diels–Alder adducts, but C–N bond cleavage predominantly occurred to give the 1:1 adducts **22** and **23** in benzene or acetonitrile or **25** and **26** in methanol, respectively. Similar reactions of neopinone dimethyl ketal (**27**) resulted in the C–N bond cleavage to give the 1:1 adducts **28** and **29**, whereas the reaction of northebaine (**30**) afforded the 1,2-addition products **31** and **32** with no C–N bond scission. On the basis of these observations, structure–reactivity relationships in these reactions are discussed.

Thebaine (1), one of the minor constituents of opium, is a highly toxic alkaloid[1] and has been mainly used in the synthesis[2-4] of codeine (2) which is the medicinally most important opiate with a low abuse potential. However, it was recently discovered that the opium-free poppy *Papaver bracteatum* contains 1 as the major constituent, constituting more than 90% of total alkaloids.[5] This fact has stimulated studies on chemical modification of thebaine (1) as a potential new raw material for analgesic agents.[5b]



1



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A unique feature of thebaine (1) is the electron-rich diene moiety in the C ring. As a result, a number of Diels–Alder reactions of 1 with olefinic dienophiles and molecular rearrangements of the resulting adducts into

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