Amidrazones 11. Rearrangement of 1-Allyl-substituted-4,5-dihydro-1-methyl-1*H*-pyrazolium Bromides [1]

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1-Methyl-2-(2-propenyl)-3-pyrazolidinimine (**5**) was obtained by treatment of 3-amino-4,5-dihydro-1-methyl-1-(2-propenyl)-1*H*-pyrazolium bromide (**4**) with ethanolic sodium ethoxide. Similar treatment of the analogous 2-(2-butenyl) and 2-(3-phenyl-2-propenyl)-substituted salts **12** and **15** gave 1-methyl-2-(1-methyl-2-propenyl)-3-pyrazolidinimine (**13**) and 1-methyl-2-(1-phenyl-1-propenyl)-3-pyrazolidinimine (**16**) respectively.

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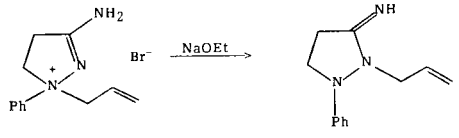
We recently reported [1] that 3-amino-4,5-dihydro-1-phenyl-1-(2-propenyl)-1*H*-pyrazolium bromide (**1**) is converted to 1-phenyl-2-(2-propenyl)-3-pyrazolidinimine (**2**) on treatment with ethanolic sodium ethoxide.

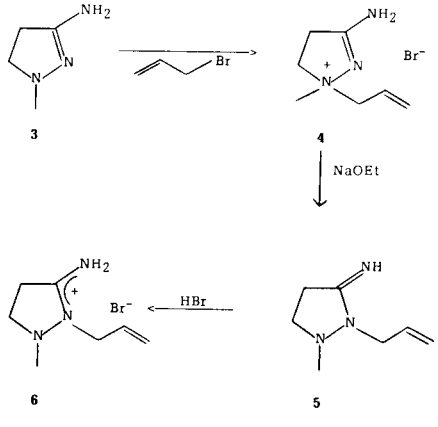


1 2

In this paper we report the analogous transformation of 3-amino-4,5-dihydro-1-methyl-1-(2-propenyl)-1*H*-pyrazolium bromide (**4**) to 1-methyl-2-(2-propenyl)-3-pyrazolidinimine (**5**) and experiments designed to probe the mechanistic aspects of these reactions.

Salt **4** was prepared by the reaction of allyl bromide with 3-amino-4,5-dihydro-1-methyl-1*H*-pyrazole (**3**). Treatment of **4** with refluxing ethanolic sodium ethoxide gave the rearrangement product **5** as a distillable, air-sensitive oil that was converted to its crystalline monohydrobromide (**6**). The ^{1}H-nmr spectrum of **6** and its analogs (**14** and **17**) display strongly deshielded NH_2^+ signals (δ 9.1-9.4) which support their assigned amidinium ion structures [3].

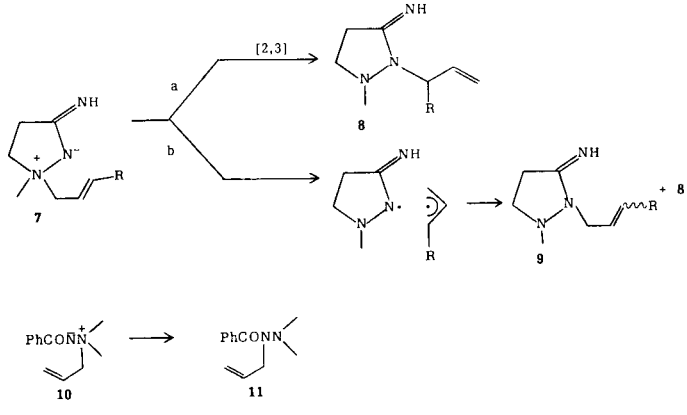
Scheme I



3 4 6 5

The conversions **1** → **2** and **4** → **5** may be regarded as Stevens-type rearrangements that occur *via* cyclic ylides that are generated by the deprotonation of **1** and **4** [4]; *i.e.* the transformation of ylide **7** (R = H) to **5** may be accounted for by either a concerted [2,3] sigmatropic rearrangement (pathway a) or a radical dissociation-recombination mechanism (pathway b). Ylides with γ-allyl substituents (**7**) would afford a single product **8** *via* the concerted pathway while the radical process should provide mixtures of **8** and **9**. Related studies have been conducted on the thermal rearrangements of allyl-substituted aminimides. Brindle and Gibson [4] have obtained convincing evidence to support a concerted pathway in the rearrangement of 1,1-dimethyl-1-(2-propenyl)-2-benzoylhydrazinium hydroxide inner salt (**10**) to 1-benzoyl-2,2-dimethyl-1-(2-propenyl)-hydrazine (**11**). Rearrangements of allylic aminimides with γ-allyl-substituents afforded products that may be accounted for by either radical processes or competititon between concerted and radical pathways [5].

Scheme II



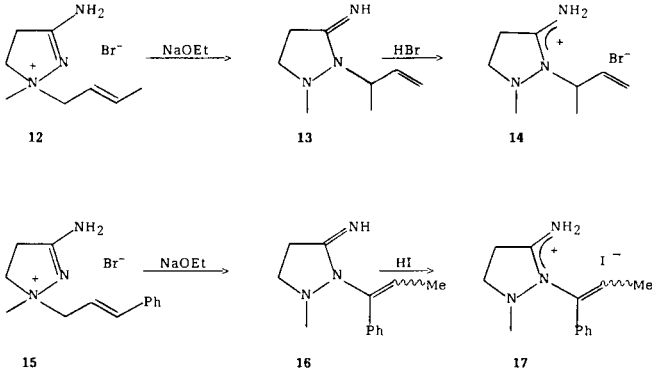
We have examined the rearrangement of two salts that would afford ylides of type **7**. 3-Amino-1-(2-butenyl)-4,5-dihydro-1-methyl-1*H*-pyrazolium bromide (**12**) was obtained by the reaction of crotyl bromide with 3-amino-4,5-dihydro-1-methyl-1*H*-pyrazole (**3**) and 3-amino-4,5-dihydro-1-(3-phenyl-2-propenyl)-1-methyl-1*H*-pyrazolium bromide (**15**) was obtained from the reaction of **3** with cinnamyl bromide.

Salt **12**, on treatment with refluxing ethanolic sodium

ethoxide, was converted to 1-methyl-2-(1-methyl-2-propenyl)-3-pyrazolidinimine (**13**). Examination of the ^{1}H-nmr spectrum of the crude product did not, within detectable limits, reveal the presence of the isomeric product, 2-(2-butenyl)-1-methyl-3-pyrazolidinimine (**9**, R = CH_3). These observations are consistent with a concerted pathway for the conversion **12** → **13**. The rearrangement product **13** was obtained as an air-sensitive, distillable oil that was converted to a stable, crystalline monohydrobromide **14**.

Analysis of the ^{1}H-nmr spectrum of the crude product obtained by rearrangement of the cinnamyl-substituted salt **15** established that the major product obtained from this reaction is 1-methyl-2-(1-phenyl-1-propenyl)-3-pyrazolidinimine **16** which could result from a base-catalyzed allylic rearrangement of the initially formed [2,3] product **8** (R = Ph). Examination of the ^{1}H-nmr spectra of the crude product also consistently revealed the presence of a minor product that displayed a very weak doublet at δ 4.0. It the doublet is due to a methylene group, the concentration of the minor product is, by integration, less than 5%. The chemical shift of the doublet is in the region expected for the allylic methylene group in the [1,2] rearrangement product **9** (R = Ph) which, if present, would most reasonably form *via* a radical mechanism (pathway b). Attempts to isolate and identify the minor product were unsuccessful. Attempted purifications of crude **16** by vacuum distillation resulted in decomposition. However treatment of the crude base with hydriodic acid afforded a crystalline, well-characterized monohydriodide **17**.

Scheme III



EXPERIMENTAL

All reactions were conducted in a nitrogen atmosphere. Melting points were determined with a Mel-Temp apparatus and are uncorrected. Infrared spectra were recorded on a Perkin-Elmer Model 710B instrument. The ^{1}H-nmr spectra were recorded on a Hitachi-Perkin Elmer 60 MHZ instrument employing hexamethyldisiloxane as the internal standard. The ^{13}C-nmr spectra were recorded on an IBM-Bruker WP 100 SY instrument.

3-Amino-4,5-dihydro-1-methyl-1-(2-propenyl)-1*H*-pyrazolium Bromide (**4**).

A reaction mixture containing 43.8 g (0.442 mole) of 1-(2-cyanoethyl)-1-methylhydrazine [6], 1.8 g of potassium hydroxide and 265 ml of 1-propanol was heated under reflux for 3 hours. The solvent was removed at reduced pressure (40°) and the residue was treated with 225 ml of dry acetonitrile. After removal of insoluble material by filtration, the solution containing 3-amino-3,4-dihydro-1-methyl-1*H*-pyrazole (**3**) was stirred and treated with 53.6 g (0.442 mole) of allyl bromide in small portions. The exothermic reaction was moderated with occasional cooling. Addition of anhydrous ether to the cooled reaction mixture gave 66.9 g (61%) of crude product as a colorless solid, mp 149-152°. Recrystallization from ethanol gave white crystals, mp 156-159°; ^{1}H-nmr (DMSO-d_6): δ 2.3-3.4 (m superimposed on a singlet at δ 3.1, 5H, H-4 and NCH_3), 3.7-4.3 (m superimposed on a doublet at δ 4.1, 4H, H-5 and CH_2-CH=), 5.3-5.9 (m, 3H, vinylic), 7.2 (bd s, 2H, NH_2^+, deuterium oxide exchangeable).

Anal. Calcd. for $C_7H_{14}BrN_3$: C, 38.2; H, 6.4; N, 19.1. Found: C, 38.1; H, 6.4; N, 19.2.

1-Methyl-2-(2-propenyl)-3-pyrazolidinimine (**5**).

A reaction mixture containing 30.0 g (0.14 mole) of salt **4**, sodium ethoxide (0.15 mole) and 300 ml of dry ethanol was heated under reflux for 6 hours. The cooled reaction mixture was filtered and the solvent removed at reduced pressure (40°). The residue was treated with 200 ml of dry benzene and insoluble material was removed by filtration. Removal of the solvent at reduced pressure (40°) gave the oily product; yield 17.5 g. Vacuum distillation afforded 10.1 g (53%) of product as a colorless oil, bp 60-70° (0.25 mm). The product darkened rapidly on exposure to air and did not give satisfactory combustion analysis data; ^{1}H-nmr (deuteriochloroform): δ 2.3-3.3 (m overlapping a singlet at δ 2.4, 7H, H-4, H-5 and CH_3N), 4.9-6.1 (m, 3H, vinylic), 3.9 (d, 2H, $CH_2CH=CH_2$), 5.8 (bd s, 1H, NH, exchangeable with deuterium oxide).

The monohydrobromide **6** was obtained by passing anhydrous hydrogen bromide into a solution containing 6.8 g of the freshly distilled free base dissolved in 50 ml of anhydrous ether. Recrystallization of the precipitated solid gave 6.5 g (60%) of **6**, mp 120-125°. Further recrystallization from ethanol gave white crystals, mp 123-125°; ^{1}H-nmr (DMSO-d_6); δ 2.6 (s, 3H, CH_3N), 3.2 (bd s, 4H, H-4 and H-5), 4.3 (d, 2H, $CH_2CH=CH_2$), 5.0-6.0 (m, 3H, vinylic), 9.2 (bd s, 2H, NH_2^+, deuterium oxide exchangeable); ir (potassium bromide): 1610, 1665, 3290 and 3350 cm^{-1}.

Anal. Calcd. for $C_7H_{14}BrN_3$: C, 38.2; H, 6.4; N, 19.1. Found: C, 38.3; H, 6.5; N, 19.2.

3-Amino-1-(2-butenyl)-4,5-dihydro-1-methyl-1*H*-pyrazolium Bromide (**12**).

This salt was prepared from crotyl bromide in a manner analogous to that described for the preparation of **4**. The crude product was obtained in 53% yield as a colorless solid, mp 160-165°. Recrystallization from ethanol gave white crystals, mp 166-168°; ^{1}H-nmr (DMSO-d_6): δ 1.7 (d, 3H, $CH_3CH=$), 2.8-3.4 (m superimposed on a singlet at δ 3.0, 5H, H-4 and N-CH_3), 3.6-4.3 (m superimposed on a doublet at δ 4.1, 4H, H-5 and NCH_2-CH=), 5.1-6.1 (m, 2H, vinylic), 7.1 (bd s, 2H, NH_2^+, exchangeable with deuterium oxide); ir (potassium bromide): 1600, 1620, 3190, 3320 and 3360 cm^{-1}.

Anal. Calcd. for $C_8H_{16}BrN_3$: C, 41.0; H, 6.9; N, 17.9. Found: C, 41.1; H, 7.0; N, 17.9.

1-Methyl-2-(1-methyl-2-propenyl)-3-pyrazolidinimine (**13**).

This compound was prepared from 25.0 g (0.11 mole) of salt **12** utilizing the procedure described for the preparation of **4**. The crude product was obtained as an oil that contained (by ^{1}H-nmr) a small quantity of benzene, yield 14.9 g. Vacuum distillation gave 7.5 g (58%) of a colorless oil that rapidly darkened on exposure to air; bp 70-75° (1.0 mm); ^{1}H-nmr (deuteriochloroform): δ 2.2 (d, 3H, CH_3CH), 2.0-3.2 (m superimposed on a singlet at δ 2.5, 7H, H-4, H-5 and N-CH_3), 4.5 (quintet, 1H, N-$CH(CH_3)CH=$), 4.8-5.2 (m, 2H, $CH_2=CH$), 5.6-6.2 (m, 1H, $CH_2=CH$), 6.3 (bd s, 1H, NH, exchangeable with deuterium oxide); ^{13}C-nmr (deuteriochloroform): 14.7 (CCH_3), 29.9 (C-4), 44.9 (CH_3N), 52.2 and 52.4 (C-5 and NCH), 112.8 ($CH=CH_2$), 133.7 ($CH=CH_2$), 166.2 (3-C); ir (film): 1620, 3080, 3270 (bd) cm^{-1}.

Anal. Calcd. for $C_8H_{15}N_3$: C, 62.7; H, 9.9; N, 27.4. Found: C, 62.3; H, 9.9; N, 27.8.

The monohydrobromide **14** was obtained in 51% yield from the free base, mp 152-158°. Recrystallization from ethanol gave white crystals, mp 162-165°; ^{1}H-nmr (DMSO-d_6): δ 1.4 (d, 3H, CH_3CH), 2.7 (s, 3H, NCH_3), 3.3 (bd s, 4H, H-4 and H-5), 4.6-6.2 (m, 3H, vinylic), 5.9 (quintet, 1H, NC*H*(CH$_3$)CH=), 9.1 (bd s, 2H, NH_2^+, exchangeable with deuterium oxide); ^{13}C-nmr (DMSO-d_6): δ 18.5 (*C*H$_3$C), 32.5 (4-C), 47.3 (CH$_3$N), 54.7 (5-C), 56.6 (N*C*H(CH$_3$)CH=), 119.3 (CH=*C*H$_2$), 137.2 (*C*H=CH$_2$), 166.2 (3-C); ir (potassium bromide): 1600, 1665, 3290 (sh) 3350 (bd) cm^{-1}.

Anal. Calcd. for $C_8H_{16}BrN_3$: C, 41.0; H, 6.9; N, 18.0. Found: C, 41.0; H, 7.1; N, 18.1.

3-Amino-4,5-dihydro-1-methyl-1-(3-phenyl-2-propenyl)-1*H*-pyrazolium Bromide (**15**).

This salt was prepared from cinnamyl bromide in a manner analogous to that described for the preparation of **4**. The crude product was obtained in 58% yield, mp 217-222° dec. Recrystallization from ethanol gave white crystals, mp 233-235 dec; ^{1}H-nmr (DMSO-d_6): δ 3.0-3.6 (m superimposed on a singlet at δ 3.3, 5H, H-4 and N-CH$_3$), 3.7-4.6 (m superimposed on a doublet at δ 4.3, 4H, H-5 and CH_2CH=), 6.1-6.7 (m, 1H, CH$_2$-C*H*=), 7.0 (d, 1H, PhC*H*=), 7.2-7.8 (m, 7H, Ph and NH_2, s at δ 7.5 exchangeable with deuterium oxide); ir (potassium bromide): 1625, 3160, 3290, 3340 cm^{-1}.

Anal. Calcd. for $C_{13}H_{18}BrN_3$: C, 52.7; H, 6.1; N, 14.2. Found: C, 52.7; H, 6.2; N, 14.4.

1-Methyl-2-(1-phenyl-1-propenyl)-3-pyrazolidinimine (**16**).

This compound was obtained from 5.0 g (0.017 mole) of salt **15** utilizing the procedure described above for the preparation of **5**. After heating the reaction mixture under reflux for 1.5 hours, the crude product was obtained as an air-sensitive oil, yield 2.9 g. The crude product decomposed on attempted vacuum distillation (0.2 mm): ^{1}H-nmr (deuteriochloroform): δ 1.7 (d, J = 7 HZ, 3H, CH_3CH=), 2.1-3.3 (m superimposed on a singlet at δ 2.7, 7H, H-4, H-5 and NCH$_3$), 5.2 (bd s, 1H,, NH exchangeable with deuterium oxide), 5.9 (q, J = 7 HZ, 1H, CH$_3$C*H*=), 7.1 (s, 5H, Ph), weak intensity impurities δ 4.0 (d) and 7.3 (benzene).

The monohydriodide **17** was obtained by the addition of 7.7 g of 47% hydriodic acid to a solution of 6.1 g of **16** in 15 ml of ethanol. Ether was added until the solution remained turbid. On cooling 5.1 g (52%) of the salt precipitated as a yellow solid, mp 203-209°. Recrystallization from ethanol gave white crystals, mp 211-214°; ^{1}H-nmr (DMSO-d_6): δ 1.8 (d, J = 7 HZ, 3H, CH_3CH=), 2.5 (s, 3H, CH$_3$N), 3.2-3.8 (m, 4H, H-4 and H-5), 6.5 (q, J = 7 HZ, 1H, CH$_3$C*H*=), 7.3 (s, 5H, Ph), 9.1 (bd s, 2H, NH_2^+, exchangeable with deuterium oxide); ^{13}C-nmr (DMSO-d_6): δ 14.3 (C*C*H$_3$), 30.6 (4-C); 42.6 (CH$_3$N), 51.4 (5-C), 125.4, 128.6, 130.0, 130.1, 132.4 (aromatic and vinyl), 163.1 (3-C); ir (potassium bromide): 1620, 1670, and 3280 (bd) cm^{-1}.

Anal. Calcd. for $C_{13}H_{18}IN_3$: C, 45.5; H, 5.3; N, 12.2. Found: C, 45.5; H, 5.3; N, 12.2.

Acknowledgment.

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REFERENCES AND NOTES

[1] Paper **10** in this series: R. F. Smith, C. J. Aquino, L. A. Olson, J. M. Galante and S. C. Liptak, *Tetrahedron Letters*, **26**, 5663 (1985).

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[3] M. D. Scott and H. Spedding, *J. Chem. Soc. (C)*, 1603 (1968).

[4] I. D. Brindle and M. S. Gibson, *J. Chem. Soc. Perkin Trans. I*, 517 (1979). These workers have reported conversion of 1,4-dimethyl-1-(2-propenyl)-3-oxopyrazolidinium tosylate (a 2-oxo analog of **4**) to 1,4-dimethyl-2-(2-propenyl)-2-pyrazolidinone.

[5] See reference [4] for a discussion of these studies.

[6] The procedure used for the conversion of 1-(2-cyanoethyl)-1-methylhydrazine to **3** is similar to that reported by H. Dorn, A. Zubek and G. Hilgetag, *Chem. Ber.*, **99**, 3377 (1965).