Thermally Induced Skeletal Rearrangement in a Triazepine

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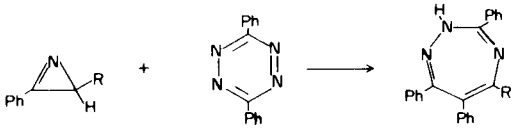
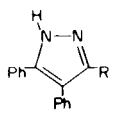
1,2,4-Triazepines **2** can be synthesized through the thermal [4 + 2] cycloaddition of 1-azirines (**1**) (1-4) with *s*-tetrazines (5,6). Thus, when 2-phenyl-1-azirine (**1a**) is treated under reflux conditions in toluene with 3,6-diphenyl tetrazine, the 1,2,4-triazepine **2a** is produced in 68% conversion as orange plates, m.p. 210°.



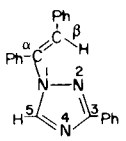
1a R H
b R CH_3

2a R H
b R CH_3

The triazepine **2a** is stable at 80° and undergoes decomposition in refluxing mesitylene to give the pyrazoles (**3a**, 29%) and (**3b**, 11%) (7,8) with elimination of PhCN and HCN respectively. In direct competition with nitrile extrusion in the thermolysis of **2a** is a remarkable skeletal rearrangement which gives a white crystalline compound, m.p. 122°, in 28% yield. Its infrared spectrum showed absorptions for a substituted C=C-H (3090, 1650 cm^{-1}) and an ultraviolet spectrum with λ max (ethanol) at 258 and 305 nm. Its mass spectrum showed prominent peaks at m/e 323 (M^+), 220, 193, 179, 178, 165, 145, 117, 103. A striking clue to the structure came from the intense peak at m/e 178 (base peak) suggesting the extreme ease of removal of Ph-C≡C-Ph as shown in **5**. Its PFT carbon-13 nmr spectrum in deuteriochloroform provided final spectroscopic establishment of structure as **4**. The phenyl carbons and C_α appeared in the normal aromatic region and we were easily able to assign C_β (121.03), C_3 (145.63) and C_5 (143.31). Bromination results in a upfield shift of C_β to 50.88 ppm. Confirmation of these assignments came from gated decoupling (9) which also gave ^{13}C-H coupling constants ($J_{C_5\text{-H}}$ 208.3 Hz, $J_{C_\beta\text{-H}}$ 133.3 Hz).



3a R H
b R Ph



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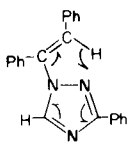

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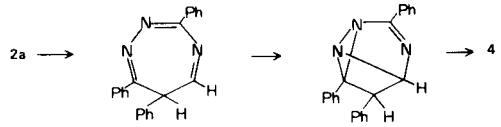
The formation of the triazolylstilbene **4** from **2a** requires an initial symmetry-allowed 1,5-sigmatropic shift of hydrogen to give **6**. Intermediate **6** can destroy itself by nitrile elimination to furnish **3**, or undergo an intramolecular [$\pi 4_a + \pi 2_a$] cycloaddition to **7** (10,11) which subsequently rearranges in a reverse Diels-Alder fashion to **4**. An alternative pathway for the formation of **4** from **6** would be an antarafacial 1,3-sigmatropic rearrangement with nitrogen inversion. The driving force in both cases is the attainment of aromatic stability.



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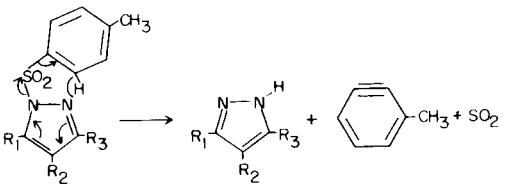
Interestingly, the triazepine **2b** undergoes rapid and quantitative conversion to the pyrazole **3b** with expulsion of acetonitrile when subjected to thermolysis at 80°.

In the course of establishing the structure of the triazepine **2a** and the pyrazoles **3**, we prepared and examined the thermal stability of their tosylates. The tosylate of triazepine **2** gave a complex mixture of products but the pyrazole tosylates **8** gave a remarkable rearrangement, with elimination of SO_2 and presumably benzyne, and the formation of starting pyrazoles **9**. A related thermal rearrangement involving allyl sulfones was recently reported by Hendrickson and Bergeron (12). We are currently examinint the scope of this thermal reaction.



8a R_1 R_2 Ph, R_3 H
b R_1 R_2 R_3 Ph

9

EXPERIMENTAL

3,6,7-Triphenyl-2*H*-1,2,4-triazepine (**2a**).

A solution of 468 mg. (4 mmoles) of 2-phenyl-1-azirine (**1a**) in

10 ml. of toluene was treated under reflux conditions with 702 mg. (3 mmoles) of 3,6-diphenyltetrazine (13,14) in 10 ml. of toluene. After 22 hours under reflux the solution had turned from cherry red to brown. It was allowed to cool to room temperature and the orange precipitate was collected and washed with pentane. The mother liquor was chromatographed on a column of silica gel and the triazepine obtained was combined with the precipitated orange material and crystallized from benzene-pentane. Pure 1,2,4-triazepine (**2a**) was obtained as shiny orange plates (664 mg., 68%): m.p. 210°; ir ν max (Nujol): 3330, 1620, 1570 cm^{-1}; ^{13}C nmr δ (deuteriochloroform-TMS): 126.03, 127.19, 127.73, 127.92, 128.31, 128.85, 131.42, 150.06; mass spectrum: m/e 323, 308, 296, 295, 220, 165, 103, 90, 77.

Anal. Calcd. for $C_{22}H_{17}N_3$: C, 81.71; H, 5.30; N, 12.99. Found: C, 81.58; H, 5.28; N, 13.02.

Tosylation of Triazepine **2a**.

The triazepine (81 mg., 0.25 mmole) in dry pyridine (5 ml.) was treated with tosyl chloride (57 mg., 0.30 mmole) and the reaction mixture was left to stand at 0° for 3 days. It was worked up by pouring over cold 2*M* hydrochloric acid (50 ml.) and subsequent extraction with ether (3 x 50 ml.). The combined ethereal extracts were washed with 2*M* hydrochloric acid and dried (sodium sulfate). Removal of solvent and crystallization of the residue from methylene chloride-pentane gave bright yellow needles (65 mg., 55%), m.p. 198-200°; ^1H nmr δ (deuteriochloroform-TMS): 2.38 (s, 3H), 6.55-8.03 (m, 20H).

Anal. Calcd. for $C_{29}H_{23}N_3SO_2$: C, 72.93; H, 4.85; N, 8.80. Found: C, 72.99; H, 4.93; N, 8.66.

5-Methyl-3,6,7-triphenyl-2*H*-1,2,4-triazepine (**2b**).

This compound was synthesized from **1b** and 3,6-diphenyltetrazine as orange needles (22%), m.p. 100° dec.; ^1H nmr δ (deuteriochloroform-TMS): 2.18 (s, 3H), 7.12-7.98 (m, 16H).

Anal. Calcd. for $C_{23}H_{19}N_3$: C, 81.87; H, 5.68; N, 12.45. Found: C, 82.11; H, 5,65; N, 11.88.

The low yields in this synthesis results from the formation under the reaction conditions of the triphenylpyrazole (**3b**) (44%).

Thermolysis of Triazepine (**2a**).

A solution of 323 mg. (1 mmole) of **2a** in 20 ml. of mesitylene was heated under reflux in a nitrogen atmosphere for 6 hours. The solvent was then removed and the residue was carefully chromatographed on preparative layer plates (silica gel PF_{254}) with 50% ether-pentane as the developing solvent. Three products were isolated. The triazolyl stilbene **4** crystallized out as white plates from ether-pentane (90 mg., 28%), m.p. 122°; ir ν max (Nujol): 3090 (C-H), 1650 (C=C) cm^{-1}; uv λ max (ethanol): 258, 305 nm; ^1H nmr δ (deuteriochloroform-TMS): 7.10 (m, 5H), 7.42 (m, 8H), 7.51 (s, 1H), 7.83 (s, 1H), 8.21 (m, J_{ortho} 8.0 Hz, 2H); ^{13}C nmr δ (deuteriochloroform-TMS): 121.03, 126.76 to 130.45 (singlets in aromatic C region), 143.31, 145.63; mass spectrum: m/e 323 (M^+), 220 (M^+-PhCN), 193 (Ph  Ph H), 178 (PhC≡CPh), 165, 145, 117  , 103 (PhCN).

Anal. Calcd. for $C_{22}H_{17}N_3$: C, 81.71; H, 5.30; N, 12.99. Found: C, 81.50; H, 5.34; N, 12.82.

The pyrazole **3a** (7,8) crystallized from ether-pentane as white needles (64 mg. 29%), m.p. 153°.

The pyrazole **3b** (7,8) crystallized from ether-pentane as white needles (34 mg., 11%), m.p. 262°.

3,4(4,5-Diphenylpyrazole Tosylate (**8a**).

This compound was prepared by tosylation of **3a** with tosyl chloride in pyridine. Crystallization from methylene chloride-ether gave white plates, m.p. 123-124°.

Anal. Calcd. for $C_{22}H_{18}N_2O_2S$: C, 70.57; H, 4.85; N, 7.48. Found: C, 70.70; H, 4.63; N, 7.36.

3,4,5-Triphenylpyrazole Tosylate (**8b**).

This compound prepared by tosylation of **3b** crystallized from methylene chloride-ether as white plates, m.p. 180°.

Anal. Calcd. for $C_{28}H_{22}N_2O_2S$: C, 74.64; H, 4.92; N, 6.22. Found: C, 75.23; H, 4.80; N, 6.18.

Thermolysis of Pyrazole Tosylate (**8a**).

This thermolysis of **8a** (165 mg.) was carried out in a sealed tube at 250° for 1 hour. The dark solid formed was separated on silica gel (PF_{254}) plates. The pyrazole **3a** was isolated in 55% yield (53 mg.), m.p. 153°.

Thermolysis of Pyrazole Tosylate (**8b**).

This thermolysis of **8b** (160 mg.) was carried out at 250° for 1 hour to give the pyrazole **3b** in 53% yield (56 mg.), m.p. 263°.

Acknowledgment.

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