The Base-induced Pyrolysis of Tosylhydrazones of Mesityl Oxide and Dypnone*[1]

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Closs, Closs, and Böll¹⁾ carried out the base-induced pyrolysis of tosylhydrazones of α,β-unsaturated aldehydes and ketones and found that the decomposition gave mainly cyclopropenes when the β-carbon atom was replaced by two alkyl groups, while it gave mainly pyrazoles when the β-carbon atom was monosubstituted or not replaced by an alkyl group. They proposed that this difference arose bacause the steric hindrance and inductive effect resulting from increasing methyl substitution at the β-position retarded the rate of cyclization of the diazo intermediates and accelerated the rate of nitrogen elimination of the diazo intermediates.

As an extension of the study concerned with the effect of substituents on the reaction routes, the base-induced pyrolysis of tosylhydrazones of mesityl oxide (I) and dypnone (V) was compared under several conditions.

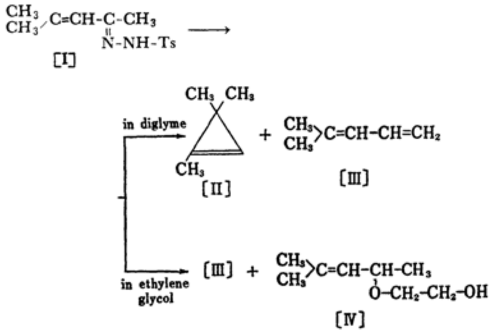

Chart 1

Mesityl oxide tosylhydrazone (I) has been known¹⁾ to give 1,3,3-trimethylcyclopropene (II) as the major product, and 4-methylpenta-1,3-diene (III) as the minor product, when added to a suspension of sodium methoxide in an aprotic solvent (diglyme) at 160°C. The pyrolysis of I with sodium alkoxides in a protic solvent (ethylene glycol) was carried out; 4-methylpenta-1,3-diene (III) and β-hydroxyethyl ether IV were obtained in ratios of 5 : 1, indicating that under these conditions nitrogen elimination was predominant.

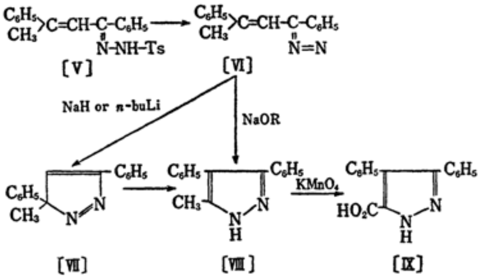

Chart 2

When dypnone tosylhydrazone (V) was added to a solution or suspension of sodium methoxide in a protic solvent (ethylene glycol) or in an aprotic solvent (diglyme), a red color developed which was attributable to the diazo intermediate VI. The red color disappeared when the solution was heated, and 5-methyl-3,4-diphenylpyrazole (VIII) was obtained quantitatively. Obviously phenyl migration occurred during the VI—VIII reaction; this migration seemed to be effected by the action of the proton from ethylene glycol or from methanol, which was formed *in situ* from the tosylhydrazone and sodium methoxide in diglyme. In support of this, the pyrolysis of V with *n*-butyllithium or sodium hydride in refluxing *n*-hexane afforded 3-methyl-3,5-diphenyl-3*H*-pyrazole (VII) in an excellent yield, and VII was rearranged into VIII when refluxed in ethanol.

The structure of VIII was established by its oxidation to the known 3,4-diphenylpyrazole-5-carboxylic acid (IX).²⁾ This pyrazolecarboxylic acid was identical with the authentic sample prepared according to the method reported by Borsche and Hahn.³⁾

Shapiro and Heath⁴⁾ and Kaufman, Cook, and Shechter⁵⁾ have reported olefin synthesis by treating tosylhydrazones with *n*-butyllithium. It should be noted that the reactions of both sodium alkoxides and *n*-butyllithium with tosylhydrazone of dypnone afforded the cyclization products

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*[1] Part V of a series on the pyrolysis of organic compounds. Part IV: T. Sato, *Tetrahedron Letters*, **1968**, 835.

1) G. L. Closs, L. E. Closs, and W. A. Böll, *J. Am. Chem. Soc.*, **85**, 3796 (1963).

2) W. E. Parham and W. R. Hasek, *J. Am. Chem. Soc.*, **76**, 799 (1954).

3) W. Borsche and H. Hahn, *Ann.*, **537**, 236 (1939).

4) R. H. Shapiro and M. J. Heath, *J. Am. Chem. Soc.*, **89**, 5734 (1967).

5) G. Kaufman, F. Cook, and H. Shechter, *ibid.*, **89**, 5737 (1967).

(VII and VIII) of the diazo intermediate VI, without any accompanying nitrogen elimination. It was concluded that, unlike the case of tosylhydrazone of mesityl oxide, the diazo intermediate VI formed by the decomposition of tosylhydrazone of dypnone was so stabilized by aromatic groups that no reaction accompanying the nitrogen elimination could be observed, even though the cyclization leading to the 3*H*-pyrazole or pyrazole might be considered to be unfavorable because of the two bulky groups on the *β*-carbon atom.

Experimental

The NMR spectra were measured on a Hitachi R-20 spectrometer in a deuterochloroform solution. The chemical shifts are described in ppm downfield from an internal tetramethylsilane reference.

Pyrolysis of Mesityl Oxide Tosylhydrazone (I). A suspension of mesityl oxide tosylhydrazone (20 g, 0.075 mol) in ethylene glycol (50 m*l*) was added, over a period of 30 to 60 min, to a solution of sodium ethylene glycolate (0.15 mol) in ethylene glycol (100 m*l*) heated to 160—190°C. The volatile matter which distilled during the addition separated into two layers. The lower layer was found by gas chromatographic analysis to be composed mainly of ethylene glycol. The upper layer (0.8—1 g) was fractionated into two components in the ratio of 5 : 1 by preparative gas chromatography on a Silicone SE 30 column at 120°C. The major component was shown to be 4-methylpenta-1,3-diene (III) from its IR and NMR spectra.[1]

NMR: δ 1.8 (m, 6H), δ 4.8 (m, 2H), δ 6.0—6.5 (m, 2H). IR: 1650, 1605, 885, 874 cm^{-1}.

The minor component was shown to be *β*-hydroxyethyl ether (IV) from its IR and NMR spectra.

NMR: δ 1.15 (d, 3H), for $C\underline{H}_3$-CH-, δ 1.70 (d, 6H) for $(C\underline{H}_3)_2C=$, δ 2.80 (s, 1H) for $-O\underline{H}$, δ 3.2—3.7 (m, 4H) for $-C\underline{H}_2-C\underline{H}_2-$, δ 3.8—4.4 (m, 1H) for $-C\underline{H}-CH_3$, δ 4.6—5.6 (m, 1H) for $-C\underline{H}=$. IR: 3600—3200 cm^{-1} for O–H, 1670 cm^{-1} for C=C, 1105 cm^{-1} for –O–, 1050 cm^{-1} for C–OH.

Dypnone Tosylhydrazone (V). A mixture of dypnone (1 g, 0.0045 mol), tosylhydrazide (0.84 g, 0.0045 mol), and concentrated hydrochloric acid (0.1 m*l*) in methanol (10 m*l*) was refluxed for 30 min. The solution was then cooled to room temperature, and the product was allowed to crystallize, filtered, and recrystallized from methanol, mp 149—150°C. Yield: 84%.

Found: C, 70.51; H, 5.99; N, 7.22%. Calcd for $C_{23}H_{22}N_2SO_2$: C, 70.77; H, 5.65; N, 7.18%.

Pyrolysis of Dypnone Tosylhydrazone (V). *a) With Sodium Methoxide in Ethylene Glycol or Diglyme.* Dypnone tosylhydrazone (1 g, 0.0025 mol) was added all at once to a solution or suspension of sodium methoxide (0.0050 mol) in ethylene glycol or diglyme (25 m*l*) heated to 160—190°C, and then the solution was refluxed for 1 hr. After the solvent had been evaporated *in vacuo*, water was added and the reaction product was extracted with ether. The ether extract was dried over anhydrous sodium sulfate, and the ether was evaporated. The product was recrystallized from benzene - *n*-hexane to give white needles of 5-methyl-3,4-diphenylpyrazole (VIII) in a 92% yield; mp 179—180°C, lit.[2] mp 185—186°C, (IR: 3400—2400 cm^{-1} for N–H, Found: C, 82.01; H, 6.15; N, 12.01%).

N-Acetyl derivative; mp 66°C.

Found: C, 78.13; H, 5.79; N, 9.94%. Calcd for $C_{18}H_{16}N_2O$: C, 78.26; H, 5.79; N, 10.15%.

b) With n-Butyllithium or Sodium Hydride in n-Hexane. Dypnone tosylhydrazone (1 g, 0.0025 mol) was added all at once to a solution or suspension of *n*-butyllithium (0.0050 mol) or sodium hydride (0.0050 mol) in *n*-hexane (15 m*l*). When the solution was heated to a boiling point, a red color indicating the formation of a diazo intermediate developed; the solution was then refluxed for 2—5 hr, during which period the red color disappeared. The solution, after being washed with water, was left to stand overnight. The crystals were filtered and recrystallized from *n*-hexane. White needles of 3-methyl-3,5-diphenyl-3*H*-pyrazole(VII) melting at 83—84°C were obtained in a yield of 90—92%.

Found: C, 81.82; H, 6.15; N, 12.17%. Calcd for $C_{16}H_{14}N_2$: C, 82.05; H, 5.99; N, 11.96%.

Oxidation of 5-Methyl-3,4-diphenylpyrazole (VIII) to 3,4-Diphenylpyrazole-5-carboxylic Acid (IX). 5-Methyl-3,4-diphenylpyrazole (0.37 g, 0.016 mol) was oxidized with potassium permanganate (0.50 g, 0.038 mol) in a mixture of water (5 m*l*) and *t*-butyl alcohol (6 m*l*) according to the method reported by Parham and Hasek[2]. A crude acid (0.07 g) melting at 254—255°C was obtained; it was identical with an authentic sample of 5-methyl-3,4-diphenylpyrazole, mp 261°C[3] (IR spectra and mixed mp).

Conversion of 3-Methyl-3,5-diphenyl-3*H*-pyrazole (VII) to 5-Methyl-3,4-diphenylpyrazole (VIII). A solution of 3-methyl-3,5-diphenyl-3*H*-pyrazole (0.5 g) in ethanol (15 m*l*) was refluxed for 1 hr. The solvent was then evaporated, and the product was recrystallized to give a 95—100% yield of 5-methyl-3,4-diphenylpyrazole.

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