Pressure-induced Synthesis of an *N*-Sulphonyl-1*H*-azepine by Sulphonyl-nitrene Insertion into Benzene

By NAGARAJ R. AYYANGAR, RAMESH B. BAMBAL, and ANANDA G. LUGADE
(*National Chemical Laboratory, Pune* 411008, *India*)

Summary The thermal decomposition of toluene-*p*-sulphonyl azide (**1**) in an excess of benzene under a nitrogen atmosphere gave *p*-tosyl-1*H*-azepine (**2**), the yield of which increased with an increase in N_2 pressure.

THERMOLYSIS of sulphonyl azides involves the initial formation of sulphonyl nitrenes. In aromatic substrates, mainly insertion-(sulphonanilides) and hydrogen abstraction-(sulphonamides) products have been obtained.[1,2] The presence of electron-withdrawing substituents in the aromatic substrates facilitates the formation of *N*-sulphonyl-1*H*-azepines.[3] In benzene, thermolysis of methanesulphonyl azide at 80 °C for 120 h gave only traces of *N*-mesylazepine (0·49%).[4] When thermolysis was carried out at 120 °C for 60 h (sealed bomb tube, 2·9 atm), *N*-mesylazepine could be isolated only as its tetracyanoethylene adduct.[4]

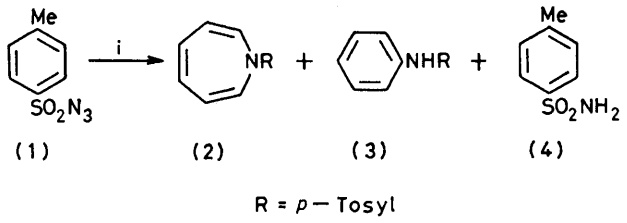
We have now achieved a facile, pressure-induced intermolecular nitrene insertion across a benzene double-bond which gives the ring-expansion product, *N*-sulphonyl-1*H*-azepine. We report herein the thermolysis of toluene-*p*-sulphonyl azide (**1**) in excess of benzene under different N_2 pressures (Scheme). In a typical experiment the azide (**1**) (16 g) and benzene (800 g) were placed in a high pressure reactor (S.S., Autoclave Engineers, Inc., U.S.A., already purged with nitrogen). The temperature was gradually raised to 155—160 °C and the nitrogen pressure was adjusted to 11·2—11·5 atm. The mixture was stirred for 2 h, cooled, and the solid, which was obtained after removal of the solvent, was chromatographed on silica gel. The chromatographic separation afforded *N*-(*p*-tosyl)-1*H*-azepine (**2**), as a yellow solid, m.p. 167 °C (decomp.) [1.0 g, 4·98%, first fraction using light petroleum–benzene (1 : 1, v/v) as

TABLE. Effect of pressure on the formation of the azepine (**2**).[a]

	N_2 pressure/atm						
Yield/%[b]	7·8	11·2	24·8—31·6	41·8	45·2—48·6	62·2	82·6—89·4
(**2**)	1·99	4·98	8·89	19·94	23·42	25·92	48·35
(**3**)	8·47	3·25	4·59	12·46	6·97	8·26	5·13
(**4**)	0·43		1·40	0·86	0·705	1·45	1·08
Isolable tar			0·65	1·20	0·30		

[a] A constant ratio of the azide (**1**) to benzene of 1 : 119·3 was used in all the cases. Reaction conditions: 155—160 °C/2 h. [b] Isolated yield (column chromatography).

eluant; lit.,[5] m.p. 169 °C], the expected nitrene-insertion product, toluene-*p*-sulphonanilide (**3**), m.p. 103 °C (0·625 g, 3·25%, second fraction using benzene as eluant; lit.,[6] m.p. 103 °C), and a trace amount of toluene-*p*-sulphonamide (**4**), m.p. 136 °C (third fraction using benzene as eluant; lit.,[7] m.p. 136 °C). Hydrogen abstraction from the solvent benzene or the product, such as the anilide (**3**), by nitrene results in the formation of the sulphonamide (**4**) along with benzyne and free-radical intermediates. The latter are responsible for the tar isolated from the reaction mixture (Table).



SCHEME. *Reagents:* i, C_6H_6, 155—160 °C, 2 h, N_2 pressure.

The structure (**2**) was confirmed by spectral and elemental analysis and by comparison of its spectral characteristics with those reported for *N*-(*p*-tosyl)-[5] and other sulphonylazepines[3,8,9] [^{1}H n.m.r. ($CDCl_3$) δ 5·75 (m, 6 H), 7·7 (m, 4 H, Ar), and 2·4 (s, 3 H, Me); ν_{max}($CHCl_3$) 1350 and 1170 (S=O), and 1640 and 1610 cm^{-1} (C=C); λ_{max}(EtOH) 223 (ε 13200), 263 (3800), and 303 nm (882); *m/e* 247 (M^+) and 92 (base peak)]. The other two products were confirmed as compounds (**3**) and (**4**) by spectral and elemental analysis and by direct comparison with authentic samples.

The Table gives the results of reactions at different nitrogen pressures, which show that azepine formation increases with an increase in pressure.

In contrast, when the thermolysis was carried out at atmospheric pressure and the reflux temperature of benzene, the sulphonylazepine (**2**) was isolated only in poor yield. Using a molar ratio of 1 : 128 and with or without the nitrogen current only 1·2% of the azepine (**2**) was isolated after 30 h. Most of the azide (**1**) remained changed. Formation of 3·25% of the anilide (**3**) occurred only after 72 h. No sulphonamide (**4**) was detected. There was no appreciable change in the yield of compounds (**2**) and (**3**) when the thermolysis was done with or without the nitrogen atmosphere. When the thermolysis was carried out under pressure, the reaction temperature of 155—160 °C appeared to be critical. In one experiment, when the reaction was carried out at 140—145 °C (41·8 atm, 2 h), using the same molar ratio, no sulphonylazepine (**2**) could be isolated. Only the anilide (**3**) (49·85%) and the amide (**4**) (1·69%) were obtained.

The azepine (**2**) (50 mg), when refluxed in benzene (20 ml) for 100 h in the presence of acidic sulphonamide (**4**) (20 mg), was found to undergo complete conversion into compound (**3**), in agreement with the suggestion of Breslow.[2a] The amount of acidic sulphonamide formed under the conditions cited in the Table was insufficient to convert the azepine (**2**) into the anilide (**3**). In another experiment, the stable benzenoid structure (**3**) was shown to undergo isomerization to its less stable 8π-electron isomer (**2**) under positive pressure [anilide (**3**) (3·0 g), benzene (800 g) at 155—160 °C/55·4—62·2 atm, 2 h]. The azepine (**2**), after storage for a month, tends to revert back to compound (**3**).

Thus a high reaction pressure, a reaction temperature of 155—160 °C, and an absence of acidic species in the reaction mixture favour the formation of the azepine in good yield.

(*Received, 25th March* 1981; *Com.* 343.)

[1] A. Bertho, T. Curtius, and F. Schmidt, *Chem. Ber.*, 1927, **60**, 1717; T. Curtius and F. Schmidt, *Chem. Ber.*, 1922, **55**, 1571; A. Bertho, *J. Prakt. Chem.*, 1928, **120**, 89.
[2] (a) D. S. Breslow, in 'Nitrenes,' ed. W. Lwowski, Interscience, New York, 1970, p. 245; (b) R. A. Abramovitch and E. P. Kyba, in 'The Chemistry of the Azido Group,' ed. S. Patai, Interscience, New York, 1971, p. 279.
[3] N. R. Ayyangar, M. V. Phatak, and B. D. Tilak, *Ind. J. Chem., Sect. B*, 1978, **16**, 547; N. R. Ayyangar, M. V. Phatak, A. K. Purohit, and B. D. Tilak, *Chem. Ind. (London)*, 1979, 853; N. R. Ayyangar, A. K. Purohit, and B. D. Tilak, *J. Chem. Soc., Chem. Commun.*, 1981, 399.
[4] R. A. Abramovitch, T. D. Bailey, T. Takaya, and V. Uma, *J. Org. Chem.*, 1974, **39**, 340.
[5] H. Prinzbach and H. Babsch, *Heterocycles*, 1978, **11**, 113.
[6] D. Elamann and E. Fabienke, *Chem. Ber.*, 1959, **92**, 712.
[7] A. L. Cordova, *An. Fac. Farm. Bioquim., Univ. Nac. Mayor San Marcos* (1950—57), 1950, **1**, 515 (*Chem. Abstr.*, 1953, **47**, 5310g).
[8] L. A. Paquette, in 'Non-Benzenoid Aromatics,' Vol. 1, ed. J. P. Snyder, Academic Press, New York, 1969, p. 250; R. K. Smalley, in 'Comprehensive Organic Chemistry,' Vol. 4, ed. P. G. Sammes, Pergamon Press, Oxford, 1979, p. 582.
[9] H. Prinzbach, G. Kaupp, R. Fuchs, M. Joyeux, R. Kitzing, and J. Markert, *Chem. Ber.*, 1973, **106**, 3824.