Selectivity in the Electrophilic Addition of Carbenes and Nitrenes to Aliphatic and Cyclic Sulphides

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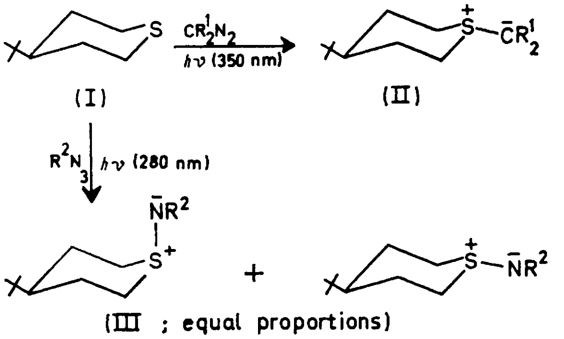
Summary. Addition of carbenes CR^1_2 (R^1 = COMe, CO_2Me, or CO_2Et) to aliphatic and cyclic sulphides to yield sulphonium ylides was highly selective, whereas the addition of nitrenes NR^2 (R^2 = p-$MeC_6H_4SO_2$ or CO_2Et) to give iminosulphuranes was quite unselective.

WE report results of an investigation of the selectivity of electrophilic addition of carbenes and nitrenes (or equivalent reactive species) to organic sulphides. The active species were made *in situ* by photolysis of solutions of the appropriate precursors in excess of sulphide (no other solvent being used); only singlet nitrenes and carbenes are reportedly[1,2b] trapped by sulphides. Addition of many carbenes to olefins shows marked selectivity associated with a combination of steric and electronic factors.[3] In contrast, only differential steric factors are likely to be operative in our work.

Reaction of 4-t-butylthiacyclohexane (I) with the carbenes CR^1_2 (R^1 = COMe, CO_2Me, or CO_2Et) photochemically generated[1] from the corresponding diazo-compounds gave in each case a single sulphonium ylide, formulated as the product (II) of equatorial addition of the carbene from consideration of the preferred steric course of alkylation of thiacyclohexanes[4] and the observed preference (described below) in additions of the carbenes to mixtures of aliphatic sulphides. That the additions were kinetically rather than thermodynamically controlled was shown by the non-equivalence of the geminal protons in the methylene groups adjacent to sulphur in the analogous ylides derived from thiacyclohexane; the n.m.r. spectra showed this effect up to 150° in nitrobenzene, indicating a substantial barrier[5] to stereochemical inversion at sulphur. An analogous result (one product, II; R^1 = COMe) was obtained from the Cu^{II}-catalysed decomposition[1] of diacetyldiazomethane in 4-t-butylthiacyclohexane; such catalysed processes are usually believed to involve the intermediacy of metal 'carbenoids' rather than carbenes. A further attempt to make a mixture of diastereoisomeric ylides from reaction of the sulphide (I) with diethyl bromomalonate followed by treatment of the expected quaternary salt (mixture?) with base failed at the first stage, although the analogous reaction with 1-methyl-4-t-butylpiperidine gave a mixture of diastereoisomeric quaternary salts in 1:1 ratio from which the mixture of corresponding ylides was prepared with sodium ethoxide in ethanol.

In marked contrast to the selectivity exhibited in the carbene reactions, reaction of the thiacyclohexane (I) with the nitrenes NR^2 (R^2 = p-$MeC_6H_4SO_2$ or CO_2Et) photochemically generated[2] from the related azides gave in each case a mixture of diastereoisomeric iminosulphuranes (III) in 1:1 ratio. Although the geminal protons in the methylene group adjacent to sulphur were not so clearly differentiated in the n.m.r. spectra as was the case with the sulphonium ylides, it is possible to deduce on other grounds that here also the product ratios correspond to kinetic control; the inversion barrier in an analogous iminosulphurane[6] is quite high (*ca.* 30 kcal mol^{-1} at 100 °C), and we note the corresponding lack of selectivity in reactions of the nitrenes with mixed aliphatic sulphides as described below, and the apparent photochemical stability of the products under the reaction conditions. We are aware that *equilibrium* mixtures of diastereoisomeric iminosulphuranes (III) would[7] also contain the components in approximately 1:1 ratio; likewise, thermodynamic control in the carbene additions would probably[4] also strongly favour the observed products (II).



The greater selectivity of the carbenes CR^1_2 in contrast to nitrenes NR^2 is presumably due to the greater degree of steric compression associated with axial entry of the effectively bulkier reagents.

The diastereoisomeric iminosulphuranes (III; $R^2 = p$-Me-$C_6H_4SO_2$) have previously caused some problems[8] in characterisation when prepared thermally, and an attempt[8] at photochemical preparation failed.

The selectivities of the carbenes and nitrenes used in the foregoing stereochemical investigations were also checked in reactions with a large excess of a 1:1 mixture of dimethyl and di-isopropyl sulphides. The mixed products, analogous to those described above, were formed in 5:1 ratio (reaction with dimethyl sulphide favoured) with the carbenes, and in 1:1 ratio with the nitrenes. We were unable to demonstrate transylidation under the preparative conditions with the toluene-*p*-sulphonylimino-derivatives, although such a process has been demonstrated[9] for a (more soluble) *N*-ethoxycarbonyliminosulphurane by prolonged irradiation at a shorter wavelength. The possibility of photochemical reversibility under irradiation at 350 nm. in the preparation of the sulphonium ylides seems even more remote.

Indicative of the speed of the reaction of the carbene $C(CO_2Et)_2$ with dimethyl sulphide was our failure to observe a transient in flash-photolysis experiments using an apparatus with a resolution of *ca.* 1 ms.[10] A similar deduction about the lifetime of the nitrene NCO_2Et is available from published work.[11] From the observed marked variation in stereoselectivity among these exceptionally active electrophiles in the reactions studied, the naïveté of any *general* expectation of low stereoselectivity in the reactions of nucleophiles with good electrophiles is quite evident, although variants of this expectation have occasionally appeared.[12]

We thank the S.R.C. for support.

(*Received*, 5*th November* 1973; *Com.* 1519.)

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[1] *Cf.* W. Ando, T. Yagihara, S. Tozune, and T. Migita, *J. Amer. Chem. Soc.*, 1969, **91**, 2786; W. Ando, T. Yagihara, and S. Tozune, *Tetrehedron Letters*, 1969, 1979; W. Ando, T. Yagihara, S. Tozune, I. Imai, J. Suzuki, T. Toyama, S. Nakaido, and T. Migita, *J. Org. Chem.*, 1972, **37**, 1721.

[2] (a) L. Horner and A. Christmann, *Chem. Ber.*, 1963, **96**, 388; (b) W. Ando, N. Ogino, and T. Migita, *Bull. Chem. Soc. Japan*, 1971, **44**, 2278.

[3] R. A. Moss in 'Carbenes,' vol. 1, eds. M. Jones, Jun., and R. A. Moss, Wiley, New York, 1973, 153; R. A. Moss in 'Selective Organic Transformations,' vol. 1, ed. B. S. Thyagarajan, Wiley, New York, 1970, 35.

[4] M. J. Cook, H. Dorn, and A. R. Katritzky, *J. Chem. Soc.* (*B*), 1968, 1467.

[5] *Cf.* D. Darwish and R. L. Tomilson, *J. Amer. Chem. Soc.*, 1968, **90**, 5938.

[6] N. Furukawa, K. Harada, and S. Oae, *Tetrahedron Letters*, 1972, 1377.

[7] *Cf.* J. B. Lambert, C. E. Mixan, and D. S. Bailey, *J. Amer. Chem. Soc.*, 1972, **94**, 208.

[8] C. R. Johnson and J. J. Rigau, *J. Org. Chem.*, 1968, **33**, 4340.

[9] Y. Hayashi and D. S. Swern, *Tetrahedron Letters*, 1972, 1921.

[10] *Cf.* Y. Yamamoto, I. Moritani, Y. Maeda, and S. Murahashi, *Tetrahedron*, 1970, **26**, 251.

[11] R. S. Berry, D. Cornell, and W. Lwowski, *J. Amer. Chem. Soc.*, 1963, **85**, 1199.

[12] *Cf.* J. McKenna, *Topics Stereochem.*, 1970, **5**, 275.