Origin of the Stereoselectivity in Salt-free Wittig Reactions

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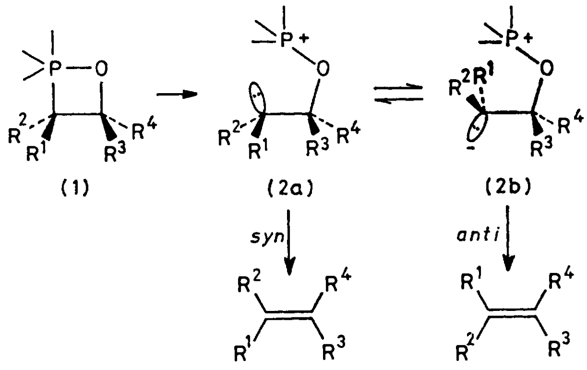
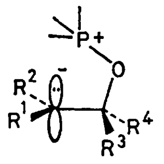
Summary The stereoselectivity of salt-free Wittig reactions is discussed in terms of a new mechanism in which the stereoselectivity arises from cleavage of the *trans*-oxaphosphetan as opposed to the formation of the *cis*-oxaphosphetan.

In recent years a number of papers have been published concerned with the Wittig reaction.[1,2] The stereoselectivity observed in salt-free Wittig reactions of non-stabilized ylides is often explained in terms of initial co-ordination of carbonyl oxygen with phosphorus[3] or $({}_{\pi}2_{a} + {}_{\pi}2_{s})$ cycloaddition[4] of ylide and carbonyl π-bonds. These mechanisms attribute the stereoselectivity to the formation of the *cis*-oxaphosphetan, which is believed to produce the *cis*-olefin. This retention of stereochemistry from oxaphosphetan to olefin is supported by the available experimental evidence.[5,6] However, this evidence derives from Wittig reactions where salt is present and thus may not be applicable to salt-free Wittig reactions. The decomposition of the oxaphosphetan (**1**) is likely to be a stepwise process in which the cleavage of the P–C bond is advanced in comparison with that of the C–O bond,[7] leading to the possibility of the carbanion-like intermediate (**2a**) and its rotamer (**2b**). Then as in the case of *E*1*cb* elimination,[8] the cleavage of the C–O bond may favour *syn*-elimination in the presence of salt but *anti*-elimination in the absence of salt. If this is the case, it should be the *trans*-oxaphosphetan that leads to the *cis*-olefin in salt-free Wittig reactions of non-stabilized ylides.



trans-Oxaphosphetans would be thermodynamically more stable than the *cis*-isomers on steric grounds and should dominate if the formation of oxaphosphetan is reversible. Even if the formation of oxaphosphetan is not reversible in the salt-free Wittig reactions of non-stabilized ylides, it is quite probable that formation of *trans*-oxaphosphetan would predominate. Since non-stabilized ylides exhibit significant carbanion but not π-bond character,[9] the incipient stage of the Wittig reaction would involve the bond formation between ylide and carbonyl carbon atoms as in a typical nucleophilic attack on carbonyl carbon. Then consideration of charge separation and steric hindrance shows the formation of *trans*-oxaphosphetan to be more likely,[3] which would lead to *cis*-olefin *via anti*-elimination.

This would imply that the rotation about the C–C bond in (**2a**) or (**2b**) is easier than either the inversion of the carbanion centre or the C–O bond cleavage, which appears reasonable.[10,11] At high temperature, inversion of the carbanion centre in (**2**) may account for the diminished stereoselectivity.[6] In the case of strongly stabilized ylides the resulting carbanion centre would be planar (**3**) because of the conjugation provided by the stabilizing substituent, so that there is no *syn–anti* dichotomy, and *trans*-olefin would result from elimination of phosphine oxide without rotation about the C–C bond.



(3)

We have explored a possible consequence of the stepwise decomposition of oxaphosphetans[7] and found the present mechanism to be consistent with the available experimental evidence.

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[1] M. Schlosser, *Topics in Stereochemistry*, 1970, **5**, 1, and references therein.

[2] A. F. Cockerill and R. G. Harrison, 'The Chemistry of Double Bonded Functional Groups,' ed. S. Patai, Wiley, New York, 1977, pp. 149—329 and references therein.

[3] W. P. Schneider, *Chem. Comm.*, 1969, 785.

[4] E. Vedejs and K. A. J. Snoble, *J. Amer. Chem. Soc.*, 1973, **95**, 5778.

[5] E. Vedejs, K. A. J. Snoble, and P. L. Fuchs, *J. Org. Chem.*, 1973, **38**, 1178.

[6] Decomposition of oxaphosphetans obtained from epoxides shows more retention than inversion of stereochemistry from oxaphosphetan to olefin (D. E. Bissing and A. J. Speziale, *J. Amer. Chem. Soc.*, 1965, **87**, 2683). However these reactions were carried out at high temperature with concomitant loss of stereoselectivity.

[7] C. Trindle, J.-T. Hwang, and F. A. Carry, *J. Org. Chem.*, 1973, **38**, 2664.

[8] D. H. Hunter and D. J. Shearing, *J. Amer. Chem. Soc.*, 1971, **93**, 2348.

[9] K. A. O. Starzewski and M. Feigel, *J. Organometallic Chem.*, 1975, **93**, C20; G. A. Gray, *J. Amer. Chem. Soc.*, 1973, **95**, 5092, 7736; D. B. Boyd and R. Hoffmann, *ibid.*, 1971, **93**, 1064; I. Absar and J. R. van Wazer, *ibid.*, 1972, **94**, 2382; M.-H. Whangbo, S. Wolfe, and F. Bernardi, *Canad. J. Chem.*, 1975, **53**, 3040; F. Bernardi, H. Schlegel, M.-H. Whangbo, and S. Wolfe, *J. Amer. Chem. Soc.*, 1977, **99**, 5633; H. Schmidbaur, *Adv. Organometallic Chem.*, 1970, **9**, 296.

[10] R. D. Bach, R. C. Badger, and T. J. Lang, *J. Amer. Chem. Soc.*, 1979, **101**, 2845.

[11] S. Wolfe, A. Rauk, L. M. Tel, and I. G. Csizmadia, *Chem. Comm.*, 1970, 96: A. Rauk, S. Wolfe, and I. G. Csizmadia, *Canad. J. Chem.*, 1969, **47**, 113; *J. Amer. Chem. Soc.*, 1969, **91**, 1567; S. Wolfe, L. M. Tel, J. H. Liang, and I. G. Csizmadia, *ibid.*, 1972, **94**, 1361.