

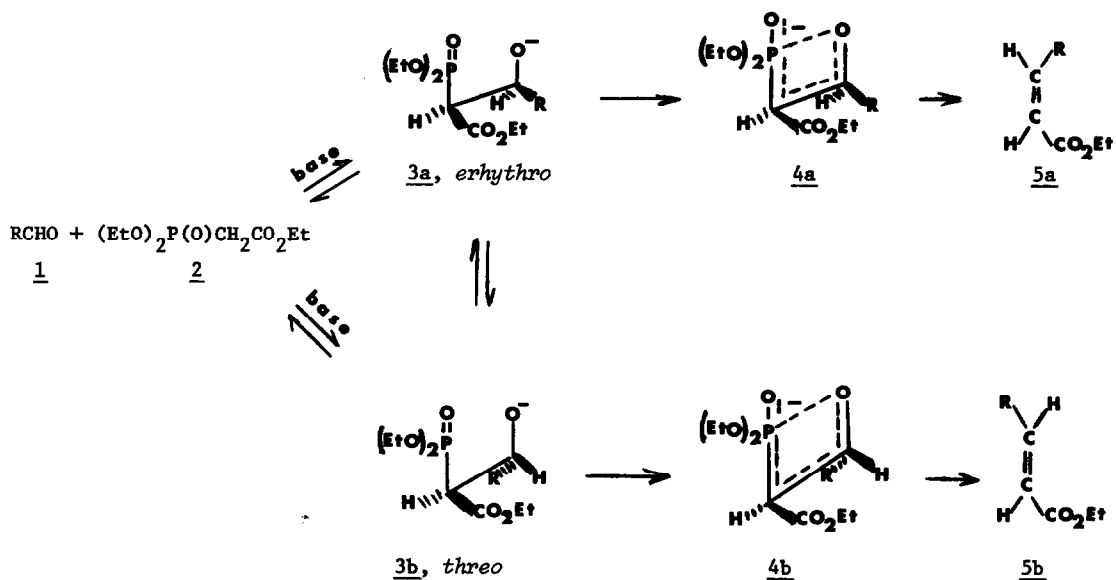
STERESELECTIVITY OF WITTIG TYPE OLEFIN SYNTHESIS USING FIVE-MEMBERED CYCLIC PHOSPHONATES.  
 PREFERENTIAL FORMATION OF *CIS* OLEFINS

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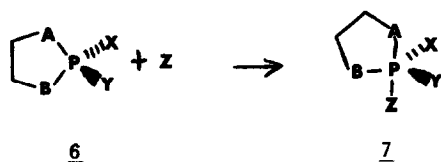
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In contrast to the Wittig reaction with non-stabilized ylids, the phosphonate modification of the Wittig reaction is known to lead predominantly to *trans* olefins.<sup>1</sup> Attempts to increase the proportion of the *cis* olefin formed in these reactions have been unsuccessful<sup>2,3</sup> excepting some reactions of phosphono ylids leading to trisubstituted olefins.<sup>4,5</sup> It is generally accepted<sup>6,7</sup> that the predominant formation of *trans* olefins in this reaction is a result of thermodynamic control upon the reversible formation and interconversion of the *erythro* and *threo* betaine (3a and 3b) and their decomposition to olefins. Kinetic<sup>8</sup> and low temperature <sup>31</sup>P nmr studies<sup>9,10</sup> of the Wittig reaction indicate the involvement of a four membered heterocyclic oxaphosphetane of type 4 as an intermediate, however there is no evidence, so far, for the formation of such an oxaphosphetane intermediate in the phosphonate or phosphinoxy modification.<sup>10</sup>

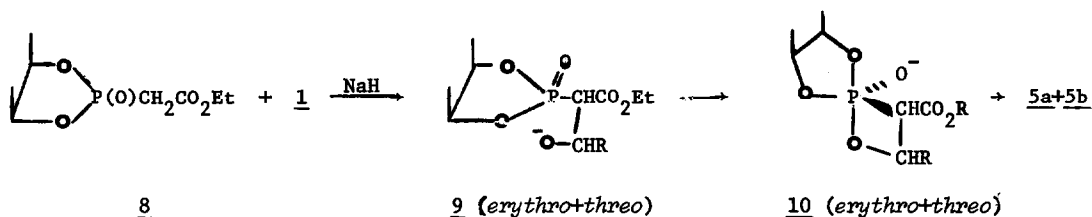


Five-membered ring phosphorus compounds of several types with tetrahedral phosphorus (6) react faster than their acyclic analogs in reactions leading to pentacoordinate intermediates (7). This has been attributed<sup>11-14</sup> mainly to release of ring strain upon passing from the tetrahedral to the trigonal bipyramid structure in which the five-membered ring occupies an apical-equatorial orientation (e.g. 6 → 7). Five-membered tetracoordinated phosphorus compounds have been reported<sup>15</sup> to enter readily



into reactions that lead to the formation of stable spirophosphoranes.<sup>16</sup> On the basis of this background and following our recent interest in the reactions of phosphonylids<sup>17</sup> we have sought to influence the steric course of phosphonate reactions

and specifically the phosphonate modification of the Wittig reaction. We have considered that this might be achieved by the use of a five-membered cyclic phosphonate. Betaine 9 derived from phosphonate 8 might be expected to undergo a more rapid ring closure to an



oxaphosphetane (10), than the betaine (3) derived from acyclic phosphonate (2), since the formation of spirophosphorane 10 would be accompanied by release of strain in the five-membered ring. Furthermore, spirophosphorane 10 thus formed would be expected to be very favorable since both the five- and four-membered rings prefer occupying apical-equatorial over diequatorial positions, while the oxide anion prefers considerably the equatorial orientation over the axial one.<sup>11-16</sup> Increased stability of the intermediate would result in lower rates of decomposition to starting materials and of interconversion of *threo* and *erythro* intermediates, consequently formation of considerable amounts of *cis* olefin could be expected.

Reaction of carbethoxymethylphosphonyldichloride with 2,3-butanediol (commercial mixture of *meso* and racemic) in the presence of triethylamine in benzene at 70° gave 25% yield of a mixture of products, C<sub>8</sub>H<sub>15</sub>O<sub>5</sub>P, b.p. 133-5° at 0.3 mm. The structure of the main

component of this was tentatively assigned as one of the two possible *meso* phosphonates 8 on the basis of  $^{31}\text{P}$ -decoupled  $^1\text{H}$  nmr spectrum, which showed an  $\text{AA}'\text{X}_3\text{X}'_3$  pattern.<sup>18</sup>

Phosphonate 8 was reacted with a series of aldehydes using sodium hydride in 1,2-dimethoxyethane at room temperature. The mixture of unsaturated esters (5a and 5b), that were obtained in 70-80% yields were analyzed by gc using a 12'x0.25" 10% Apiezon L on Diatoport 60-80 column. A pure sample of each product was isolated by preparative scale gc and structures were assigned on the basis of nmr and ir spectra. For comparison, we reacted most aldehydes with triethyl phosphonoacetate (2). The results of these reactions along with some results from the literature are listed in the Table.

TABLE  
RESULTS FROM THE REACTIONS OF ALDEHYDES WITH PHOSPHONATES

<u>Reactants</u>		<u>Products</u>	
<u>1</u>		<u>5a</u>	<u>5b</u>
R in RCHO	phosphonate	$\begin{array}{c} \text{R} \quad \text{CO}_2\text{Et} \\ \diagdown \quad / \\ \text{C}=\text{C} \\ / \quad \diagdown \\ \text{H} \quad \text{H} \end{array}$	$\begin{array}{c} \text{R} \quad \text{H} \\ \diagdown \quad / \\ \text{C}=\text{C} \\ / \quad \diagdown \\ \text{H} \quad \text{CO}_2\text{Et} \end{array}$
$\text{C}_2\text{H}_5$	<u>8</u>	55	45
$\text{C}_2\text{H}_5$	<u>2</u>	0	100
$n\text{-C}_3\text{H}_7$	<u>8</u>	52	48
$n\text{-C}_3\text{H}_7$	<u>2</u>	0	100
$n\text{-C}_3\text{H}_7^3$	<u>2</u>	0	100
$i\text{-C}_3\text{H}_7$	<u>8</u>	68	32
$i\text{-C}_3\text{H}_7$	<u>2</u>	7	93
$i\text{-C}_3\text{H}_7^4$	<u>2</u>	0	100
$i\text{-C}_3\text{H}_7^{19}$	<u>2</u>	31	69
$n\text{-C}_4\text{H}_9$	<u>8</u>	57	43
$\text{C}_6\text{H}_5$	<u>8</u>	60	40
$\text{C}_6\text{H}_5$	<u>2</u>	0	100
$p\text{-ClC}_6\text{H}_4$	<u>8</u>	58	42
$p\text{-CH}_3\text{OC}_6\text{H}_4$	<u>8</u>	50	50

Examination of the data listed in the Table, reveals that reactions of cyclic phosphonate 8 with aldehydes lead to the formation of *cis* olefins (5a) in excess over the *trans* isomers (5b), indicating the lack of thermodynamic control upon the formation and

interconversion of the intermediates. In our view this can be interpreted in terms of the existence of the spiranic oxaphosphetane, 10 rather than the strained betaine 9 as intermediate in the reactions of phosphonate 8.

Wittig reactions of some five-membered cyclic phosphonium ylids were studied previously. <sup>8,20,21</sup>

A similar approach to this problem has been taken by Deschamps, Lampin, Matthey and Seyden-Penne.<sup>22</sup> We thank Dr. Seyden-Penne for exchanging information prior to publication.

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