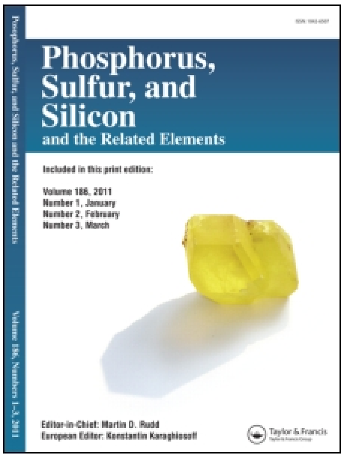


**Phosphorus, Sulfur, and Silicon and the Related Elements**
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713618290

# Thiophosphates and Selenophosphates in Organic Synthesis. A New Approach to Exocyclic Olefins and Bicyclic Enones.

Aleksandra Skowrońska; Ewa Krawczyk; Marek Koprowski; Piotr Dybowski

**To cite this Article** Skowrońska, Aleksandra , Krawczyk, Ewa , Koprowski, Marek and Dybowski, Piotr(1996) 'Thiophosphates and Selenophosphates in Organic Synthesis. A New Approach to Exocyclic Olefins and Bicyclic Enones.', Phosphorus, Sulfur, and Silicon and the Related Elements, 109: 1, 409 — 412

**To link to this Article: DOI:** 10.1080/10426509608545177

**URL:** http://dx.doi.org/10.1080/10426509608545177

*Phosphorus, Sulfur, and Silicon,* 1996, Vols. 109–110, pp. 409–412
Reprints available directly from the publisher
Photocopying permitted by license only

# THIOPHOSPHATES AND SELENOPHOSPHATES IN ORGANIC SYNTHESIS. A NEW APPROACH TO EXOCYCLIC OLEFINS AND BICYCLIC ENONES.

*ALEKSANDRA SKOWROŃSKA,* EWA KRAWCZYK, MAREK KOPROWSKI AND PIOTR DYBOWSKI*

Centre of Molecular and Macromolecular Studies, Polish Academy of Sciences,
90-363 Łódź, Sienkiewicza 112, Poland

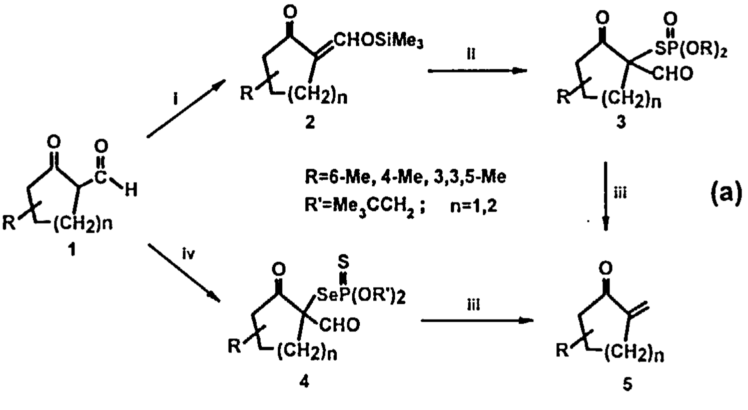
Abstract: Efficient synthesis of α-methylene-cycloalkanones, α-methylene-lactones and α-alkylidene-lactones as well as bicyclic enones were developed using thiophosphates **3**, **9**, **15** and selenophosphates **4** as key intermediates.

We have recently reported a new methodology for stereoselective conversion of carbonyl compounds into various functionalized (Z)-olefins[1] via readily available S-(2-oxoalkyl)thiophosphates,[2] S-(2-oxo-3-alkenyl)thiophosphates[3] and their seleno analogues.[4]

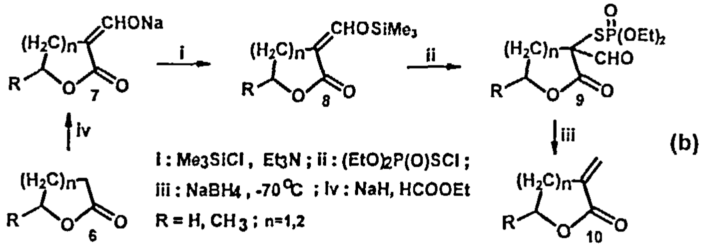
Herein we present an extention of this useful approach to the synthesis of α-methylene-cycloalkanones, α-methylene-lactones, and bicyclic enones.

α-Methylene-lactones and α-methylene-cycloalkanones are key elements of many naturally occurring sesquiterpenes or antibiotics.[5] It is not very surprising that numerous procedures have been developed for effecting α-methylenation of various carbonyl compounds.[6]

Our approaches are outlined in Scheme 1 and Scheme 2. The carbonyl compounds **1** and **7** when first O-silylated, are thiophosphorylated using $(RO)_2P(O)SCl$; this provides efficient synthesis of both new thiophosphates **3** and **9**. Selenophosphates **4** have been prepared by other protocol, the treatment of cycloalkanones **1** with $(RO)_2P(S)SeBr$ in the presence of pyridine. As expected selective reduction of the aldehyde function of phosphates **3**, **4** and **9** using $NaBH_4$ proceeded smoothly to give α-methylene-cycloalkanones **5**, α-methylene-γ-lactones and α-methylene δ-lactones **10**.

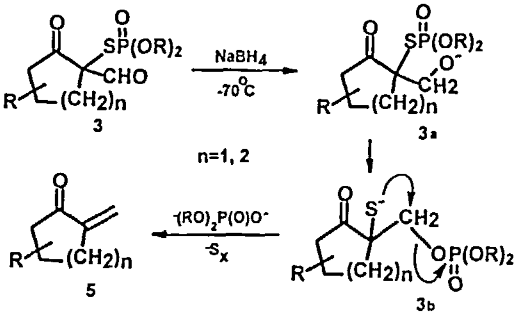


i : $Me_3SiCl$, $Et_3N$ ; ii : $(EtO)_2P(O)SCl$ ; iii : $NaBH_4$, -70°C ; iv: $(R'O)_2P(S)SeBr$, Py



Scheme 1

The transformation of the thiophosphates 3, 4 and 9 into cycloalkenones 5 and lactones 10 is exemplified in Scheme 2.

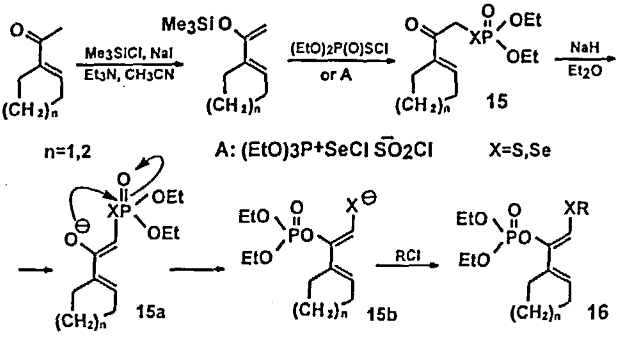


Scheme 2

The reaction of the thiophosphate 3 with sodium borohydride results in the formation of the oxyanions 3a. The intermediates 3a undergo rearrangement involving migration of a phosphoryl group from sulfur to oxygen affording thiolate anions 3b. Subsequent cyclization of 3b with the elimination of phosphate anion, and spontaneous desulfurization of resulting episulfide afford α-methylene-cycloalkanones 5.

It is noteworthy, that all syntheses presented above can be performed as a 'one pot reaction'. The simple protocol, efficiency and mild conditions make the reactions described here attractive alternatives to known for the α-methylenation.

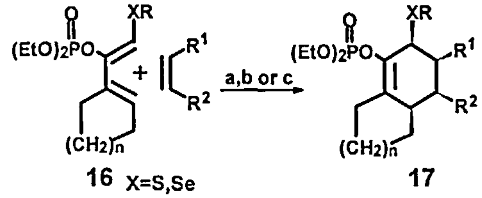
We have been also successful in the synthesis of dienes 16 containing both alkylthio (acylthio, dialkoxyphosphorylthio or diphenoxyphosphorylthio) and diethoxyphosphoryloxy substituents from readily available thiophosphates 15 (Scheme 3).



Scheme 3

Treatment of thiophosphates **15** with NaH affords enolate anions **15a** which undergo rearrangement to thiolates **15b**. The latter react with a number of electrophiles producing desired dienes **16** in good yield.

Cycloaddition of these new dienes **16** to a variety of dienophiles either in toluene solution at reflux or under Lewis acid catalysis produce the corresponding adducts in good yield. All the cycloadditions studied proceed with complete regio- and (endo)-stereoselectivity. In every case the functional group of dienophile is oriented 'orto' to the sulfide group of the diene. Here, the regiochemistry of cycloaddition is controlled by the sulfur substituent. Analogous regiocontrol by phenylthio group has been observed in the Diels-Alder reaction of several alkoxy- and acyloxy-phenylthiobutadienes.[7] The structure and configuration of the adducts **17** (see Scheme 4) were determined on the basis of $^1$H (including COSY experiments), $^{13}$C, $^{31}$P, IR and high resolution MS data.



R1 = CN, R2 = H
R1 = Ac, R2 = H
R1, R2 = C(O)NPhC(O)
R1, R2 = C(O)OC(O)
R1 = C(O)OMe, R2 = C(O)OMe
R1 = $COCH_2SP(O)(OEt)_2$, R2 = H
R1, R2 = C(O)CH=CHC(O)

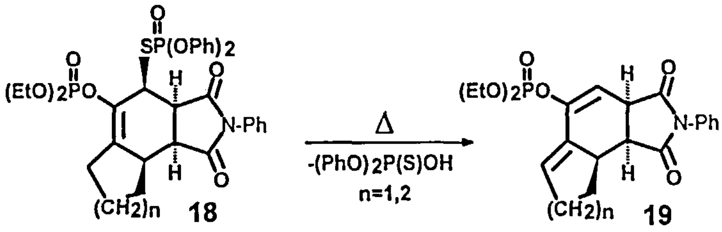
Conditions: a: 100°C, toluene b: 70°C, $ZnBr_2$, toluene c: from -78°C to 0°C, $EtAlCl_2$,$CH_2Cl_2$

Scheme 4

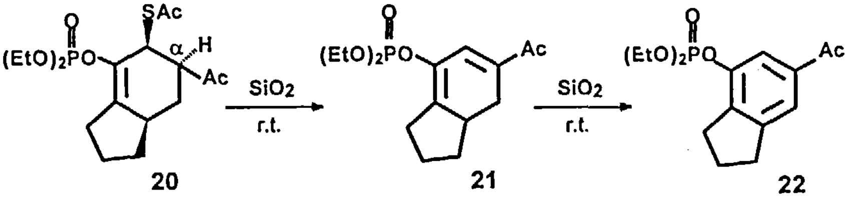
The synthetic utilities of this new annelating procedure are manifold:

1. The sulfur substituent of adducts **17** can be easily removed. We have made two interesting and useful observations:

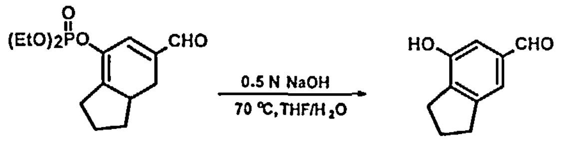
a) Adducts **18** containing an excellent leaving group like $(PhO)_2P(O)S$ undergo spontaneous elimination under conditions of cycloaddition to produce the new 1,3-dienes **19**.

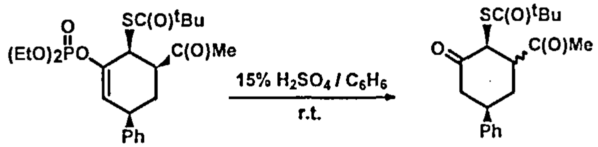


b) An efficient way to catalyzed elimination of sulfur substituent is to deposit the adducts in 5:1 $CCl_4$/ethyl acetate solution on silica gel at r.t. overnight, but after a further 12 h the 1,3-dienes **21** aromatize to **22**.



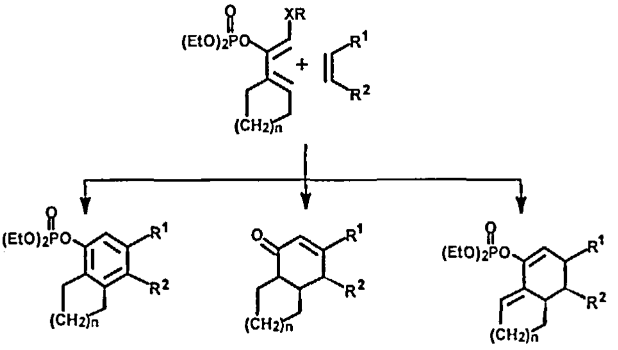
2. The diethoxyphosphoryloxy group can be removed by the action of $NH_4F$ or alternatively by basic or acid catalyzed hydrolysis.[8]





3. The regiochemistry observed here complements the regiochemistry obtained with 2-alkoxyphosphoryloxy dienes.[8]

4. We have demonstrated that Diels-Alder additions of dienes 16 to dienophiles can be used as convenient route to bicyclic enones, enol phosphates and aromatic phosphates. The reaction course depends on the substituents in the diene and dienophile as well as the reaction conditions.



**Acknowledgment.** The financial support of this work from the Polish State Committee for Scientific Research (KBN) under Grants No 2 1325 9101 and 2 2668 9203 is gratefully acknowledged.

## REFERENCES

1. P.DYBOWSKI, A.SKOWROŃSKA, Heteroatom Chemistry, 2, 55, (1991); P.DYBOWSKI, A.SKOWROŃSKA, Tetrahedron Lett., 32, 4385, (1991); A.SKOWROŃSKA, P.DYBOWSKI, E.KRAWCZYK, Phosphorus, Sulfur and Silicon, 75, 27, (1993).
2. P.DYBOWSKI, A.SKOWROŃSKA, Synthesis, (1990), 609.
3. P.DYBOWSKI, M.KOPROWSKI, E.KRAWCZYK, A.SKOWROŃSKA, in press.
4. P.DYBOWSKI, E.KRAWCZYK, A.SKOWROŃSKA, Synthesis (1992), 601.
5. P.A.GRIECO, Synthesis, (1975), 57; H.M.R.HOFFMANN, Angew.Chem. Int.Ed.Engl. 24, 94, (1985).
6. M.TRAMONTINI, Synthesis, (1973), 703; N.PETRAGNANI, H.M.C.FERREZ, G.V.J.SILVA, Synthesis, (1986), 157; M.B.M. DE AZEVEDO, A.E.GREENE, Synth.Commun., 24, 495, (1993).
7. T.COHEN, Z.KOSARYCH, J.Org.Chem., 47, 4005, (1982); B.M.TROST, J.IPPEN, W.C.VLADUCHIK, J.Am.Chem.Soc., 99, 8117, (1977); B.M.TROST, W.C.VLADUCHIK, A.J.BRIDGES, J.Am.Chem. Soc., 102, 3554, (1980).
8. H.J.LIU, W.M.FENG, J.B.KIM, N.C.BROWNE, Canad.J.Chem., 72, 2163, (1994).