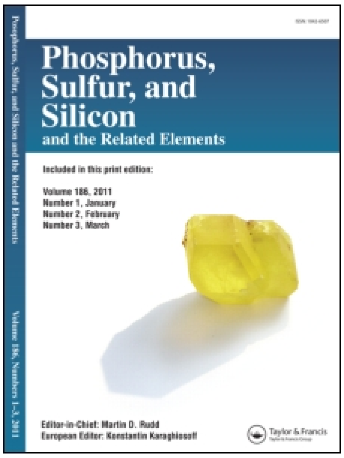

Phosphorus, Sulfur, and Silicon and the Related Elements
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713618290

REDUCTION OF THIONOESTERS TO ETHERS BY TRIORGANOTIN HYDRIDES

Colin Smith[a]; Linda M. Tunstad[a]; Carlos G. Gutierrez[a]
[a] Department of Chemistry and Biochemistry, California State University, Los Angeles, California

To cite this Article Smith, Colin , Tunstad, Linda M. and Gutierrez, Carlos G.(1988) 'REDUCTION OF THIONOESTERS TO ETHERS BY TRIORGANOTIN HYDRIDES', Phosphorus, Sulfur, and Silicon and the Related Elements, 37: 3, 257 — 260

To link to this Article: DOI: 10.1080/03086648808079047

URL: http://dx.doi.org/10.1080/03086648808079047

Phosphorus and Sulfur, 1988, Vol. 37, pp. 257–260
Reprints available directly from the publisher
Photocopying permitted by license only

COMMUNICATION

REDUCTION OF THIONOESTERS TO ETHERS BY TRIORGANOTIN HYDRIDES

COLIN SMITH, LINDA M. TUNSTAD and CARLOS G. GUTIERREZ*
Department of Chemistry and Biochemistry California State University, Los Angeles, California 90032

(Received January 28, 1988)

Esters **1** are efficiently deoxygenated to the corresponding ethers **3** in two steps by first conversion to the thionoesters **2** and subsequent reduction of these by triorganotin hydrides.

Esters are readily converted to thionoesters by a variety of recently reported methods.[1,2,3] Our continuing interest in desulfurization of organosulfur compounds by organotin hydrides[4,5,6] prompted the present study, and we now report that thionoesters **2** are reduced to the corresponding ethers **3**[7] in high yield by two equivalents of tri-*n*-butyltin hydride (TBTH). This represents the overall deoxygenation of simple esters **1** to ethers **3** (equation 1).[8]

$$\begin{tikzcd}
\underset{\mathbf{1}}{R^1C(=O)OR^2} \arrow[r] \arrow[ddr] & {} & & & & \\
& & \underset{\mathbf{3}}{R^1CH_2OR^2} & + & (Bu_3Sn)_2S & (1) \\
& \underset{\mathbf{2}}{R^1C(=S)OR^2} \arrow[ur, "TBTH"] \arrow[r] \arrow[dr, "TBTH"'] & \underset{\mathbf{4}}{R^1C(=O)SR^2} \arrow[rr] & & \underset{\mathbf{5}}{R^1C(=S)SR^2} & (2) \\
& & R^2H & + & R^1C(=O)SSnBu_3 & (3)
\end{tikzcd}$$

A set of esters **1**, where R^1 and R^2 included primary, secondary, and aryl groups, was reacted with Lawesson's reagent [(4-methoxyphenyl)thioxophosphine sulfide][1] to produce the corresponding thionoesters **2**. These were subsequently reduced with two equivalents of TBTH to the ethers **3**, as summarized in the Table.

The preparation of thionoesters **2** was initially accomplished by reacting 6 mmol of esters **1** with 10 mmol Lawesson's reagent in 4 ml of refluxing xylene. The progress of the thionation reactions (10–17 hrs) was monitored by ^1H NMR (for example, in xylene, the OCH_3 singlet in methyl benzoate **1a** appears at 3.0 ppm, while the OCH_3 in thionoester **2a** resonates at 3.3 ppm relative to external TMS) and/or thin layer chromatography. The products were isolated by passing the reaction mixture through a short column of silica gel to give **2** and an accompanying 5–10% of the dithio esters **5**. These over-thiated products apparently resulted from a rearrangement of **2** to thiolo ester **4**,[9,10] which was

TABLE
Conversion of esters to thionoesters and their subsequent reduction with TBTH to ethers

	Ester **1**		Thiono Ester **2**		Ether **3**	
Entry	R^1	R^2	Entry	Yield	Entry	Yield
1a	Ph	CH_3	**2a**	90	**3a**	85
1b	Ph	CH_2CH_3	**2b**	79	**3b**	82
1c	CH_3	Ph	**2c**	96	**3c**	87
1d	CH_3	$c\text{-}C_6H_{11}$	**2d**	87	**3d**	80
1e	$n\text{-}C_{13}H_{27}$	$i\text{-}C_3H_7$	**2e**	82	**3e**	92
1f	2-furyl	CH_3	**2f**	93	**3f**	0

then thionated by Lawesson's reagent to the dithio ester **5**, (Equation 2). The production of **5** appears to be concentration dependent: neat reaction of methyl benzoate (**1a**) with Lawesson's reagent resulted in a mixture consisting of equal parts unreacted **1a** (OCH_3 singlet at $\partial = 3.7$ ppm in CCl_4), O-methyl thionobenzoate **2a** (OCH_3 singlet at $\partial = 4.15$ ppm; C_8H_8OS $m/z = 152$), and thiomethyl thionobenzoate (SCH_3 singlet at $\partial = 2.7$ ppm; $C_8H_8S_2$ $m/z = 168$). On the other hand, the use of 20 ml of xylene solvent in the thionation step eliminated the production of over-thiated material **5**. The yields reported in the Table for compounds **2** are for reactions run under these more dilute conditions. Attempted thionation of dimethyl malonate resulted in formation of intractible material.

The reduction of thionoesters **2** with 2.1 equivalents of TBTH was done in benzene solvent, with azobisisobutyronitrile (AIBN) as initiator.[4,5,6] Progress of the reduction was conveniently monitored by NMR: the loss of the tributyltin hydride Sn-H resonance at 4.5 ppm (in benzene) and of the thionoester O-alkyl signal and the appearance of product ether signals. The Table lists NMR yields for product ethers **3**, using diphenylmethane as internal standard. Isolation of the products was achieved either by careful chromatography on silica gel or by distillation. The identity of the product ethers **3** was established by comparison with authentic samples which were either obtained commercially or were prepared by alkylation of the appropriate alkoxide with an alkyl halide. The TBTH reduction of 2-furyl derivative **2f** did not yield the desired ether, but rather unknown products which were not characterized.

The reaction of TBTH with cyclic thionocarbonates to produce 1,3-heterocycles has been reported.[11] More pertinent to the present work, the reduction of thionoesters by organotin hydrides has been previously described by Barton[12] and others[13] as a procedure for the deoxygenation of alcohols to hydrocarbons (Equation 3). Consonant with that synthetic goal, R^1 groups were purposefully selected by those workers as to bias thionoesters **2** towards homolysis of the O—R^2 bond. Thionoesters in these cases included thiocarbonyl imidazolides, xanthate esters, and thionobenzoate esters. It is noteworthy that thionobenzoate esters **2a** and **2b**, in our hands, did not undergo fragmentation of the O—R^2 bond, but rather desulfurization *via* Equation (1). The differences in reaction conditions may account for the different pathways taken. Where alcohol deoxygenation was desired, the investigators reacted the thionobenzoates at xylene or toluene reflux with low concentrations of organotin hydride (added slowly over a 2 h period). We produced benzyl alkyl ether **3a** (or **3b**) by the simultaneous mixing of thionobenzoate **2a** (or **2b**) and two equivalents of TBTH at benzene reflux.

A report[3] on the thionation of esters by bis(tricyclohexyltin) sulfide and BCl_3 suggested to us an attractive procedure wherein organotin compounds can be used for both the thionation and reduction processes, and furthermore that these organotin reagents may be recycled. We produced methyl thionobenzoate (**2a**) in 70% yield from the reaction of bis(tricyclohexyltin) sulfide/BCl_3 with methyl benzoate (**1a**). Tricyclohexyltin chloride precipitated in the reaction mixture and was isolated in 85% yeild. Reduction of **2a** with tricyclohexyltin hydride (prepared from tricyclohexyltin chloride and lithium tetrahydroaluminate) produced benzyl methyl ether (**3a**) in 72% yield after Kugelrohr distillation from the non-volatile bis(tricyclohexyltin) sulfide byproduct. The organotin species in this process is recycled: the bis(tricyclohexyltin) sulfide is converted, in the thionation step, to tricyclohexyltin chloride. This in turn becomes the starting material for making the tricyclohexyltin hydride required for the reduction step. The organotin product of the last step is bis(tricyclohexyltin) sulfide.

ACKNOWLEDGEMENT

We thank the National Institutes of Health [NIGMS-MARC (GM 08228) and MBRS-DRR (SO6 RR-08101)] for support of this work.

REFERENCES

1. For a review of ester (and ketone and amide) thionation with Lawesson's reagent, see: M. P. Cava, *Tetrahedron* **41,** 5061 (1985).
2. For a review of the synthesis and reduction of thionoesters see: B. A. Jones and J. S. Bradshaw, *Chem. Rev.* **84,** 17 (1984).
3. K. Steliou and M. Mrani, *J. Am. Chem. Soc.* **104,** 3104 (1982).
4. C. G. Gutierrez, R. E. Stringham, K. G. Glasscock, and T. Nitasakka, *J. Org. Chem.* **45,** 3393 (1980).
5. C. G. Gutierrez, C. P. Alexis, and J. M. Uribe, *J. Chem. Soc. Chem. Comm.* 124 (1984).
6. C. G. Gutierrez, and L. R. Summerhays, *J. Org. Chem.* **49,** 5206 (1984).
7. For the desulfurization of thionoesters to ethers by Raney nickel see: S. L. Baxter and J. S. Bradshaw, *J. Org. Chem.* **46,** 831 (1981); J. S. Bradshaw, B. A. Jones, and J. S. Gebhard, *J. Org. Chem.* **48,** 1127 (1983); B. A. Jones, J. S. Bradshaw, P. R. Brown, J. J. Christensen, and R. M. Izatt, *J. Org. Chem.* **48,** 2635 (1983). The reduction of thionoesters by sodium borohydride yields only alcohols and thiols, reference 10.
8. Several other reagents have been used to deoxygenate esters (mostly lactones) to ethers including, trichlorosilane under ultraviolet irradiation: S. Baldwin, and S. A. Hant, *J. Org. Chem.* **40,** 3885 (1975); J. Tsurugi, R. Nakano, and T. Fukumoto, *J. Am. Chem. Soc.* **91,** 4587 (1969); Y. Nagata, T. Dohmaru, and J. Tsurugi, *J. Org. Chem.* **38,** 795 (1973); borane reagents: G. R. Pettit, and T. R. Kasuri, *J. Org. Chem.* **25,** 875 (1960); G. R. Pettit, and D. M. Piatak, *J. Org. Chem.* **27,** 2127 (1962); lithium aluminum hydride/aluminum chloride mixtures: A. M. Maione, and I. Torrini, *Chem. Ind.* 837 (1975); A. M. Maione, and M. G. Quaglia, *Chem. Ind.* 230 (1977); sodium borohydride: S. Takano, and K. Ogasawara, *Synthesis* 42 (1974); D. M. Bailey, and R. E. Johnson, *J. Org. Chem.* **35,** 3574 (1970). A two step approach involving the initial reduction of the ester with diisobutylaluminum hydride (DIBAL) followed by reductive deoxygenation with triethylsilane in the presence of boron trifluoride etherate has been reported: G. A. Kraus, K. A. Frasier, B. D. Roth, M. J. Taschener, and K. Neuenschwender, *J. Org. Chem.* **41,** 2417 (1981).

9. S. Scheitauer, and R. Mayer, "Thio- and Dithiocarboxylic Acids and their Derivatives" in *Topics in Sulfur Chemistry*; A Senning, Ed. (Thieme: Stuttgart, 1979) Vol. 4.
10. A. B. A. G. Ghattas, E. E. A. M. El-Khrisy, and S. O. Lawesson, *Sulfur Lett.* **1,** 69 (1982).
11. D. R. Williams and J. L. Moore, *Tetrahedron Lett.* 339 (1983).
12. D. H. R. Barton, and J. McCombie, *J. Chem. Soc. Perkin Trans.* **1** 1574 (1975); D. Forrest, K. U. Ingold, and D. H. R. Barton, *J. Phys. Chem.* **81,** 915 (1977); D. H. R. Barton, W. B. Motherwell, and A. Stange, *Synthesis* 743 (1981); D. H. R. Barton, and W. B. Motherwell, *Pure Appl. Chem.* **53,** 15 (1981).
13. B. Lythgoe, and I. Waterhouse, *Tetrahedron Lett.* 4223 (1977); M. H. Beak, P. Gaslien, P. S. Kirkwood, and J. McMillan, *J. Chem. Soc. Perkin Trans.* **1,** 885 (1980); C. K. Thiem, *Chem. Ber.* **113,** 3039 (1980); D. J. Hart, *J. Org. Chem.* **46,** 367 (1981); J. R. Rasmussen, *J. Org. Chem.* **45,** 2725 (1980).