Dipole-Stabilized Carbanions from Esters: α-Oxo Lithiations of 2,6-Substituted Benzoates of Primary Alcohols

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Received March 2, 1981

The synthetic utility of dipole-stabilized carbanions from esters is illustrated by the preparations, α-oxo lithiations, electrophilic substitutions, and cleavages of the 2,4,6-triisopropylbenzoates and the 2,6-bis(dimethylamino)-3,5-diisopropylbenzoates of primary alcohols, **2** and **3**, respectively. Typical electrophiles used in this methodology include primary alkyl halides, aldehydes, ketones, trimethylsilyl chloride, and tri-*n*-butyltin chloride. Cleavages of the substituted esters of **2** are accomplished with lithium aluminum hydride while hydrolyses of derivatives of **3** can be achieved under acidic conditions. The 2,6-substitutions of **2** and **3** are considered to enforce orthogonality of the carbonyl group and the phenyl ring and thereby to inhibit addition to the carbonyl by the organolithium base used for the metalation by placing the substituents in the trajectory for nucleophilic addition along the LUMO of the carbonyl. The acidic hydrolysis of **3** under conditions where **2** is stable is attributed to protonation of the dimethylamino group which provides subsequent assistance for nucleophilic addition. These metalations provide the key steps in the preparation of secondary α-lithio alcohol synthetic equivalents from primary alcohols. Lithiation of 1′-methylbenzyl 2,4,6-triisopropylbenzoate proceeds α to oxygen as expected, but attempts to prepare analogous unactivated tertiary α-lithio esters were unsuccessful. The lithiation of 2′-methoxyethyl 2,4,6-triisopropylbenzoate is followed by elimination of methoxide and α-oxo metalation of the resulting vinyl ester. Lithiation of allyl 2,4,6-triisopropylbenzoate provides 1-(2,4,6-triisopropylphenyl)-1,2-butanedione by rearrangement.

Many formally dipole-stabilized carbanions are α-heteroatom metalloorganics which have special synthetic value.[1] In this report we detail the α-oxo lithiations of 2,6-substituted benzoates, a reaction which is the key step in a sequence that allows electrophilic substitution of the α-hyrogen of a primary alcohol.

A four-step sequence for electrophilic substitution of a primary alcohol at the α-carbon to give a substituted secondary alcohol is shown in Scheme I. The initial, penultimate, and final steps of alcohol acylation, reaction of an organolithium with an electrophile, and ester cleavage, are well-known. The third step, metalation of an ester adjacent to oxygen to provide the dipole-stabilized carbanion **1**, is less precedented.[1,2] This report details the reactions outlined in Scheme I with emphasis on the third step, the lithiation of 2,6-substituted benzoates.[3] This work provides a secondary α-lithio alcohol synthetic equivalent from a primary alcohol. Like many cases of inversion of the usual reactivity patterns, this approach provides a new conversion which could affect synthetic strategies.[4]

The electrophilic substitution illustrated in Scheme I by a dashed arrow has not been a synthetically viable process. The most direct preparation of α-oxo organometallics by proton removal from the corresponding carbon acid has been unsuccessful for alcohol derivatives except for the allyl and vinyl ethers in which stabilization of the formal carbanion is provided by unsaturation.[5] Indirect preparations of α-oxo organometallics which are masked α-lithio alcohols from aldehydes by the sequence of stannylation, trapping, and tin-lithium interchange have been reported by Seebach and Still and used extensively by Still.[6]

(1) Beak, P.; Reitz, D. B. *Chem. Rev.* **1978**, *78*, 275.

(2) For cases in which transient formation of α-oxo organometallic esters is reported, see: Upton, C. J.; Beak, P. *J. Org. Chem.* **1975**, *40*, 1094. Olofson, R. A.; Lotts, K. D.; Barber, G. N. *Tetrahedron Lett.* **1976**, 3381.

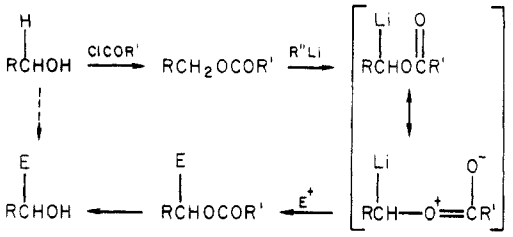
(3) The α-oxo metalations of (a) methyl 2,4,6-triisopropylbenzoate (Beak, P.; McKinnie, B. G. *J. Am. Chem. Soc.* **1977**, *99*, 5213), (b) methyl 2,4,6-tri-*tert*-butylbenzoate (Schlecter, R.; Seebach, D.; Lubosch, W. *Helv. Chim. Acta.* **1978**, *91*, 512), and (c) ethyl 2,4,6-triisopropylbenzoate (Beak, P.; Baillargeon, M.; Carter, L. G. *J. Org. Chem.* **1978**, *43*, 4255) have been previously communicated.

(4) For discussion of "umpollung" or charge affintiy inversion in synthetic strategy, see: Corey, E. J. *Pure Appl. Chem.* **1967**, *14*, 19; Evans, D. A.; Andrews, G. C. *Acc. Chem. Res.* **1974**, *7*, 147; Seebach, D. *Synthesis* **1977**, 357. In the present case, electrophilic substitution is achieved at a carbon which would customarily be susceptible to nucleophilic substitution.

(5) (a) For vinyl cases, see: Schollkoph, U.; Hanssle, P. *Justus Liebigs Ann. Chem.* **1972**, *763*, 208; Baldwin, J. E.; Hoffle, G. A.; Lever, O. W., Jr. *J. Am. Chem. Soc.* **1974**, *96*, 7125; Hartmann, J.; Stahle, M.; Schlosser, M. *Synthesis* **1974**, 888; Earnshaw, C.; Wallis, C. J.; Warren, S. *J. Chem. Soc., Perkin Trans.* 1 **1979**, 3099; Soderquist, J. A.; Hassner, A. *J. Am. Chem. Soc.* **1980**, *102*, 1577; Dexheimer, E. M.; Spialter, L. *J. Organomet. Chem.* **1976**, *107*, 229; Boeckman, R. K., Jr.; Bruza, K. J.; Baldwin, J. E.; Lever, O. W. *J. Chem. Soc., Chem. Commun.* **1975**, 519; Boeckman, R. K., Jr.; Bruza, K. J. *J. Org. Chem.* **1979**, *44*, 4751; Chavdarian, C. G.; Heathcock, C. H. *J. Am. Chem. Soc.* **1975**, *97*, 3822; Levy, A. B.; Schwartz, S. J. *Tetrahedron Lett.* **1976**, 2201; Brandsma, L.; Strating, J. In "Methoden der Organische Chemi (Houben-Weyl)"; Georg Thieme Verlag: Stuttgart, 1966; Vol. 4, p 109; Schlosser, M.; Schneider, P. *Angew Chem., Int. Ed. Engl.* 1979, *18*, 489; Lebouc, A.; Delaunay, J.; Riobe, O. *Synth. Commun.* **1979**, 610; Rautenstrauch, V. *Helv. Chim. Acta* **1972**, *55*, 594; Clinet, J. C.; Linstrumelle, G. *Tetrahedron Lett.* **1978**, 1137; Leroux, Y.; Mantione, R. *Ibid.* **1971**, 591, 593; Gange, D.; Magnus B. P.; Clardy, J.; Bass L.; Arnold, E. V.; Clardy, J. *J. Am. Chem. Soc.* **1980**, *102*, 2134; Olsson L. I.; Claesson, A. *Acta, Chem. Scand., Ser. B* **1976**, *30*, 521; Gould, S. J.; Remillard, B. D. *Ibid.* 4353 (1978). (b) For allyl cases, see: Dimmel, D. R.; Gharpure, S. B. *J. Am. Chem. Soc.* **1971**, *63*, 3991; Hartmann, J.; Muthukrishnan, R.; Schlosser, M. *Helv. Chim. Acta* **1974**, *57*, 2261; Evans, D. A; Andrews, G. C.; Buckwalter, B. *J. Am. Chem. Soc.* **1974**, *96*, 5560; Evans, D. A.; Baillargeon, D. J.; Nelson, J. V. *Ibid.* **1978**, *100*, 2242; Evans, D. A.; Takacs, J. M.; Hurst, K. M. *Ibid.* **1979**, *101*, 371; Still, W. C. *Tetrahedron Lett.* **1976**, 2115; Still, W. C., MacDonald, T. L. *J. Am. Chem. Soc.* **1974**, *96*, 5561; Still, W. C.; MacDonald, T. L. *J. Org. Chem.* **1976**, *41*, 3620; Rasmussen, J. K. *Synthesis* **1977**, 91; Hosomi, A.; Hashimoto, H.; Sakurai, H. *J. Org. Chem.* **1978**, *43*, 2551; Yamamoto, Y.; Maruyama, K. *J. Am. Chem. Soc.* **1978**, *100*, 6283; Yamamoto, Y.; Maruyama, K. *Yuki Gosei Kagaku Kyokaishi* **1979**, 641. (c) For Wittig rearrangement following metalation, see: Wittig, G.; Lohmann, L. *Justus Liebigs Ann. Chem.* **1950**, *550*, 260; Patai, S. "The Chemistry of the Ether Linkage"; Interscience: London, 1967; p 618; West, R.; Lowe, R.; Stewart, H.; Wright, A. *J. Am. Chem. Soc.* **1971**, *93*, 282; Felkin, H.; Tambute, A. *Tetrahedron Lett.* **1969**, 821; Rautenstrauch, V. *Helv. Chim. Acta* **1972**, *55*, 594; Courtois, G.; Miginiac, L. *Tetrahedron Lett.* **1972**, 2411; Dimmel, D. R.; Huang, S. *J. Org. Chem.* **1973**, *38*, 2756; Rauchenstrauch, V.; Buchi, G.; Wuest, H. *J. Am. Chem. Soc.* **1974**, *96*, 2576. (d) For Brook rearrangement following metalation, see: Brook, A. *Acc. Chem. Res.* **1974**, *7*, 77; Wright, A.; West, R. *J. Am. Chem. Soc.* **1974**, *96*, 3214; Reich, H. J.; Rusek, J. J.; Olson, R. E. *Ibid.* **1979**, *101*, 2225; Kuwajima, I.; Kato, M. *J. Chem. Soc., Chem. Commun.* **1979**, 708. (e) For carbenoid formation from an α-halo ether, see: Olofson, R. A.; Lotts, K. D.; Barber, G. *Tetrahedron Lett.* **1976**, 3779; Barber, G. N.; Olofson, R. A. *Ibid.* **1976**, 3793. (f) For fragmentation of tetrahydrofuran, see: Maercker, A.; Theasohn, W. *Justus Liebig Ann. Chem.* **1971**, *747*, 70.

0022-3263/81/1946-2363$01.25/0

Scheme I



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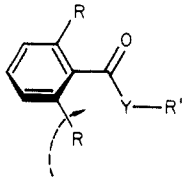
Results and Discussion

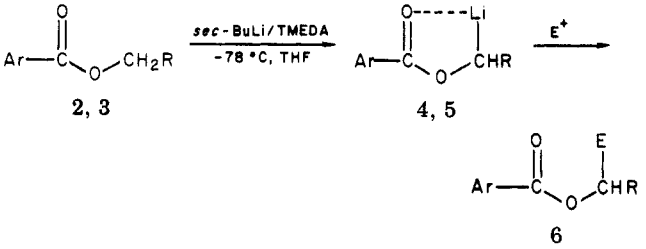
The hypothesis that a carbonyl group bonded to a heteroatom can provide dipole stabilization for formation of a carbanion adjacent to the heteroatom has been supported for esters, thioesters, and amides by experiment and theory.[1-3,7-9] Both approaches also suggest that complexation of the lithium ion to the carbonyl oxygen is an important factor in the stabilization of these organolithiums. The early cases of self-addition of α-heteroatom metalated benzamides and thiobenzoates led to the development in our laboratories, and independently in those of Seebach, of sterically hindered 2,6-substituted benzamides, thiobenzoates, and benzoates as systems in which nucleophilic addition to the carbonyl is sufficiently suppressed to allow the direct formation of stable, trappable, α-heteroatom organolithium reagents.[7,9] Our rationale for the use of 2,6-disubstituted benzoates followed from the expectation that with such substitution the carbonyl group would assume a conformation perpendicular to the plane of the benzene ring such that the trajectory for nucleophilic addition to the LUMO of the carbonyl group would be highly disfavored.[10]



trajectory for a nucleophile

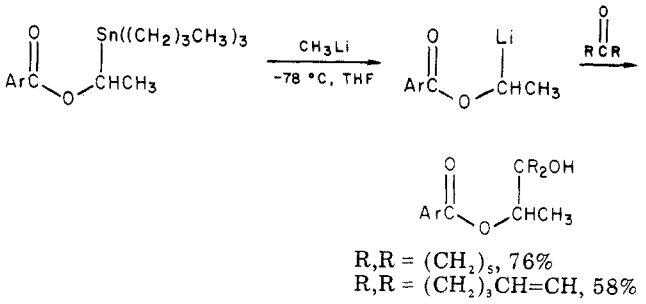
For the sequence illustrated in Scheme I to be useful the hindrance of the carbonyl toward nucleophilic addition must be in careful balance. The carbonyl carbon should be accessible for preparation of the initial ester and

Scheme II[a]



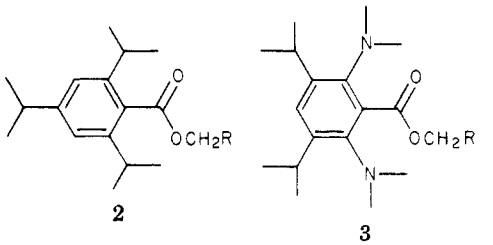
[a] For 2 and 4, Ar = 2,4,6-triisopropylphenyl, and for 3 and 5, Ar = 2,6-bis(dimethylamino)-3,5-diisopropylphenyl.

Scheme III[a]



R,R = $(CH_2)_5$, 76%
R,R = $(CH_2)_3CH{=}CH$, 58%

cleavage of the substituted ester, but there must be also sufficient steric hindrance to prevent nucleophilic addition to the carbonyl by the metalating base. We can report two derivatives of primary alcohols, the 2,4,6-triisopropyl benzoates (2) and the 2,6-bis(dimethylamino)-3,5-diiso-



propylbenzoates (3), that meet this criteria. This paper illustrates the use of these esters as secondary α-lithio alcohol synthetic equivalents.

Syntheses of 2,6-Substituted Benzoates. Conversion of 2,4,6-triisopropylbenzoic acid to the acid chloride followed by reaction with an alcohol gave the following esters 2 in the yields indicated: ethyl (88%), *n*-propyl (72%), isopropyl (59%), *n*-octyl (72%), benzyl (95%), 2′-methoxyethyl (56%), and 2′-(*N*,*N*-dimethylamino)ethyl (83%).[11] Substitution at the carbonyl carbon of the acid chloride is clearly feasible. Preparation of esters of 2,4,6-triisopropylbenzoic acid and of 2,6-bis(dimethylamino)-3,5-diisopropylbenzoic acid[12] could also be carried out under phase-transfer conditions by displacement of the carboxylates on alkyl bromides or iodides.[13] That procedure provided the following esters of 2 in the yields indicated: ethyl (89%), *n*-propyl (84%), isopropyl (47%), *n*-octyl (62%), *n*-hexadecyl (81%), and allyl (87%). The following esters of 3 were also obtained: methyl (90%), ethyl (77%), *n*-pentyl (79%). The high yields under basic phase-transfer conditions can be taken to suggest that the carbonyl groups in these benzoates are somewhat sterically

(6) (a) From aldehydes: Still, W. C. *J. Am. Chem. Soc.* **1978**, *100*, 1481; Still, W. C.; Sreekumar, C. *Ibid.* **1980**, *102*, 1201; Seebach, D.; Meyer, N. *Angew. Chem., Int. Ed. Engl.* **1976**, *15*, 438; Meyer, N.; Seebach, D. *Chem. Ber.* **1980**, *113*, 1290. (b) From α-halo ethers: Runge, F.; Taeger, E.; Fiedler, C.; Kahlert, E. *J. Prakt. Chem.* **1963**, *291*, 37; Welge, P. M.; Clark, R. D.; Heathcock, C. H. *J. Org. Chem.* **1976**, *41*, 3144; Still, W. C.; Mitra, A. *J. Am. Chem. Soc.* **1978**, *100*, 1927.

(7) Beak, P.; Brubaker, G. R.; Farney, R. F. *J. Am. Chem. Soc.* **1976**, *98*, 3621. Beak, P.; Farney, R. F. *Ibid.* **1973**, *95*, 4771. Beak, P.; McKinnie, B. G.; Reitz, D. B. *Tetrahedron Lett.* **1977**, 1839. Reitz, D. B.; Beak, P.; Farney, R. F.; Helmick, L. S. *J. Am. Chem. Soc.* **1978**, *100*, 5428 and references cited therein.

(8) Rodan, N. G.; Houk, K. N.; Beak, P.; Zajdel, W. J., Chandrasekhar, J.; Schleyer, P. v. R., submitted for publication.

(9) Steric hindrance has been shown by the Zurich group to be useful in providing a number of α-amide organolithiums which function as α-lithiomethylamine synthetic equivalents. Seebach, D.; Lubosch, W. *Angew. Chem., Int. Ed. Engl.* **1976**, *15*, 313. Schlecter, R.; Seebach, D. *Helv. Chim. Acta* **1977**, *60*, 1459. Hassel, T.; Seebach, D. *Ibid.* **1979**, *61*, 2237. Seebach, D.; Hassel, T. *Angew. Chem., Int. Ed. Engl.* **1978**, *17*, 274. Seebach, D.; Hassel, T. *Ibid.* **1979**, *18*, 399.

(10) For discussion of the effect of 2-substitution on amide rotation, see: Jones, P. R., Weisman, G. R., Baillargeon, M. J., Gosink, T. A., *J. Org. Chem.*, *45*, 3618 (1980) and references cited therein. Staab, H. A.; Laver, D. *Chem. Ber.* **1968**, *101*, 864. These authors showed that with sterically hindered 2,6-disubstituted tertiary benzamides, rotational isomers can be isolated.

(11) Fuson, R. C.; Horning, E. C. *J. Am. Chem. Soc.* **1938**, *60*, 2063.

(12) The synthesis of this acid is outlined in Scheme IX and is described in the Experimental Section.

(13) Larson, F. C. V.; Lawesson, S.-O. *Tetrahedron* **1972**, *28*, 5341; Demlow, E. V. *Angew. Chem., Int. Ed. Engl.* **1974**, *13*, 170.

Table I. Conversions of 2,4,6-Triisopropylbenzoates 2 to Substitutes Esters 6

R for reactant ester 2	electrophile	E for product ester 6	yield,[a] %
CH_3	deuteriomethanol	D	87 (95)
CH_3	allyl bromide	$CH_2CH{=}CH_2$	62 (80)
CH_3	1-iodobutane	$(CH_2)_3CH_3$	50 (79)
CH_3	chlorotri-*n*-butyltin	$Sn[(CH_2)_3CH_3]_3$	53 (85)
CH_3	chlorotrimethylsilane	$Si(CH_3)_3$	64 (94)
CH_3	acetone	$HOC(CH_3)_2$	87 (95)
CH_3	acetone-d_6	$HOC(CD_3)_2$	67 (74)
CH_3	cyclohexanone	$HOC(CH_2)_5$	31 (50)
CH_3	2-cyclohexene-1-one	$HOCCH{=}CH(CH_2)_3$	59
CH_3	acetaldehyde	$HOCHCH_3$	65 (90)
CH_3	*N,N*-dimethylmethyleneammonium iodide	$CH_2N(CH_3)_2$	42 (58)
CH_2CH_3	deuteriomethanol	D	64 (95)
CH_2CH_3	acetone	$HOC(CH_3)_2$	43 (57)
CH_2CH_3	allyl bromide	$CH_2CH{=}CH_2$	67 (90)
$(CH_2)_6CH_3$	deuteriomethanol	D	73 (43)
$(CH_2)_6CH_3$	allyl bromide	$CH_2CH{=}CH_2$	64 (93)
$(CH_2)_6CH_3$	chlorotrimethylsilane	$Si(CH_3)_3$	72 (90)
$(CH_2)_6CH_3$	acetone	$HOC(CH_3)_2$	52 (55)
$(CH_2)_{14}CH_3$	deuteriomethanol	D	(7)
$(CH_2)_{14}CH_3$	acetone	$HOC(CH_3)_2$	(10)
C_6H_5	methyl iodide	CH_3	85 (45)
$CH_3CHC_6H_5$	methyl iodide	CH_3	63
$CH_2N(CH_3)_2$	deuteriomethanol	D	82
$CH_2N(CH_3)_2$	1-iodobutane	$(CH_2)_3CH_3$	

[a] Yields are based on starting ester; yields in parentheses are for crude products.

Table II. Conversions of the 2,6-Bis(dimethylamino)-3,5-diisopropylbenzoates 3 to Substituted Esters

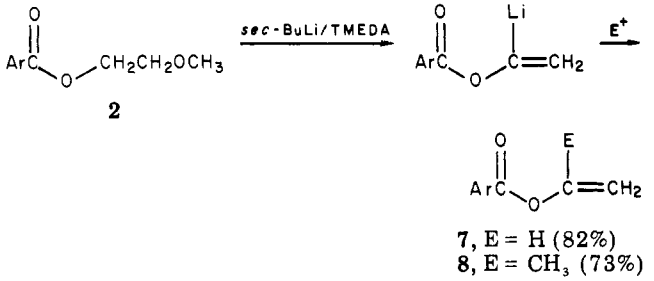
R for reactant ester 3	electrophile	E for product ester 6	yield,[a] %
H	deuteriomethanol	D	90
CH_3	deuteriomethanol	D	71
CH_3	allyl bromide	$CH_2CH{=}CH_2$	67 (90)
CH_3	chlorotri-*n*-butyltin	$Sn[(CH_2)_3CH_3]_3$	50 (90)
CH_3	chlorotrimethylsilane	$Si(CH_3)_3$	88 (95)
CH_3	acetone-d_6	$HOC(CD_3)_2$	71 (73)
$(CH_2)_3CH_3$	deuteriomethanol	D	80

[a] Yields are based on starting ester; yields in parentheses are for crude products.

protected since ester hydrolysis is observed for unhindered cases under comparable conditions.[14] The ethyl and isopropyl esters of **2** and **3** were also prepared by halogen–lithium interchange of the corresponding aryl bromide with *n*-butyllithium followed by reactions with diethyl carbonate or the appropriate chloroformate.

Metalations of 2,6-Substituted Benzoate Esters. The novel and critical step in Scheme I is the metalation of the esters **2** and **3** adjacent to oxygen. For both compounds the most effective conditions for achieving this reaction involve the use of excess *sec*-butyllithium–tetramethylethylenediamine (*sec*-BuLi/TMEDA) at −78 °C in tetrahydrofuran for 5–6 h.[15] As shown in Scheme II and Table I, the ethyl, *n*-propyl, *n*-octyl, *n*-hexadecyl, benzyl, 1′-methylbenzyl, and 2′-(*N,N*-dimethylamino)ethyl esters of **2** can be metalated and the lithiated species **4** treated with a variety of electrophiles to give substituted products **6** in reasonable yields. Products were purified by chromatography and characterized by spectral and analytical

Scheme IV



7, E = H (82%)
8, E = CH_3 (73%)

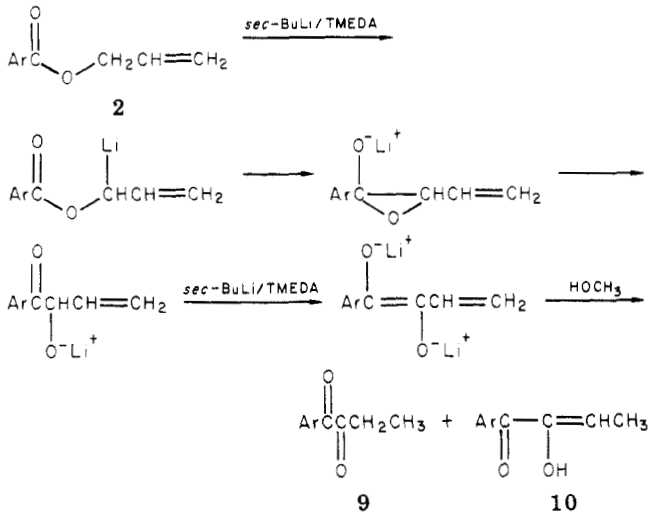
methods. Table II provides the details of the lithiations and subsequent electrophilic trapping of the methyl, ethyl, and *n*-pentyl esters of **3**.

For cases in which the use of excess reagents is undesirable, the metalated ester **4** can be formed by treatment of the previously prepared 1′-(tri-*n*-butylstannyl)-substituted benzoate with a slight excess of methyllithium for 30 min at −78 °C[3c] (Scheme III). The strategy is illustrated for reaction with cyclohexanone and 2-cyclohexenone. Only the product of 1,2-addition is observed in the later case. By this modification the use of TMEDA and/or an excess of the electrophile can be avoided.

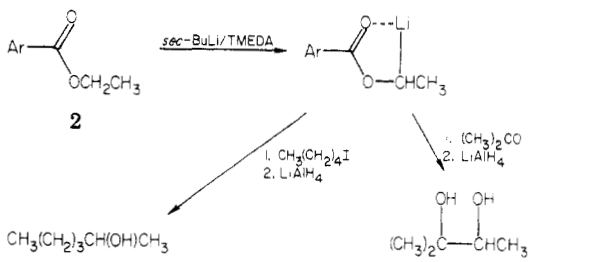
The results summarized in Tables I and II show that **4** and **5** react as expected with the usual electrophiles. The recovered ester from the reaction with acetone-d_6 showed incorporation of one deuterium; enolization of the substrate is competitive with addition in that case. Modification of the solvent by addition of 10% hexamethylphosphoric triamide prior to the addition of deuteriomethanol, allyl bromide, or acetone provides 5–20% increases in yields of crude products, but product purification is less convenient. The use of benzylic halides as electrophiles led to a dimer of the organolithium, and the use of hindered nitriles, vinyltriphenylphosphonium bromide, or bromine provided none of the expected products. Attempts to prepare the lithioorganocopper from **4** with cuprous iodide followed by attempted reactions with a variety of prospective electrophiles or carbenoid trapping species led to 2,4,6-triisopropylbenzoic acid as the only identified species, in substantial yields in most cases.

(14) Starks, C. M. *J. Am. Chem. Soc.* **1971**, *93*, 195.
(15) For a discussion of the variation in metalation conditions and other details of these reactions, see: Carter, L. G. Ph.D. Thesis, University of Illinois, 1980 (available from University Microfilms, Ann Arbor, MI). Metalation in the absence of TMEDA gave some of the phenone expected from nucleophilic addition to the carbonyl. Other organolithiums were less effective in metalation.

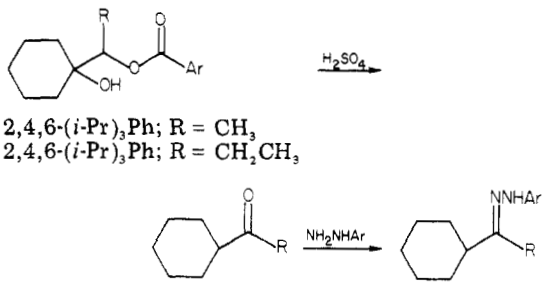
Scheme V



Scheme VI



Scheme VII



11, Ar = 2,4,6-(i-Pr)$_3$Ph; R = CH_3
12, Ar = 2,4,6-(i-Pr)$_3$Ph; R = CH_2CH_3

Lithiations of the 2′-(dimethylamino)ethyl and benzyl esters **2** could be conveniently achieved in 1 h. Presumably stabilization of **4** by complexation and conjugation is effective in the respective transition states for deprotonation. On the other hand, although the octyl ester of **2** undergoes efficient metalation, the reaction of the *n*-hexadecyl ester gave only low yields under the prescribed conditions.

Lithiation of the 2-methoxyethyl ester of **2** with excess *sec*-BuLi/TMEDA occurs in 1 h, but the products obtained on reaction with methanol or methyl iodide respectively are **7** and **8** (Scheme IV). Initial metalation is followed by elimination of methoxide and α-oxo deprotonation of the resulting vinyl ester to give the vinyl organolithium which leads to the observed products.

Lithiation of the allyl ester of **2** provides a 20:80 protomeric mixture of **9** and **10** in 53% yield (Scheme V). This rearrangement is attributed to intramolecular addition of the organolithium to the carbonyl group followed by ring opening and double bond migration as shown. The stability of the other metalated esters and of the corresponding lithiated allyl ethers[3b] is in interesting contrast to this rearrangement.

Attempts were made to lithiate the isopropyl esters of **2** and **3** in order to extend this methodology to tertiary systems. Under the usual conditions no reaction of the esters was observed. Reaction of isopropyl 2,4,6-triisopropylbenzoate with 8 equiv of *sec*-butyllithium–potassium *tert*-butoxide[16] for 2 h at 0 °C did provide, in addition to the phenone expected for addition of *sec*-butyllithium, a small amount of a compound tentatively assigned the structure 2-hydroxy-2-methyl-1-(2,4,6-triisopropylphenyl)-1-propanone on the basis of IR and mass spectral data. Apparently metalation has been followed by a rearrangement analogous to that observed with the allyl ester.

In contrast to the metalations of the esters of **2** and **3**, we have found that the ethyl 2,4,6-triethylbenzoate, ethyl 2,6-bis(dimethylamino)benzoate, and ethyl 2,6-dimethoxybenzoate are not satisfactory substrates for α-oxo metalation.[15] The first ester undergoes lithiation at both the α-oxo and benzylic positions while the latter two react by addition of the *sec*-butyllithium to the ester to provide the expected phenone.[15]

Cleavage of the Substituted Esters of 1 and 2. The results in Tables I and II show that α-oxo lithiation of appropriately substituted esters is possible and that the resulting organolithiums are useful nucleophilic species in reactions with typical electrophiles. Utilization of this chemistry to provide an α-lithio alcohol synthetic equivalent, as in Scheme I, requires not only the synthesis of the ester from the alcohol and acid chloride but also the cleavage of the substituted ester to the substituted alcohol. While formation of the esters from the acid chloride and the alcohol demonstrate that addition to the carbonyl carbon is possible, the fact that the carbonyl group is effectively hindered toward nucleophilic addition by *sec*-butyllithium suggests the usual hydrolysis might not be successful. In fact, the esters of 2,4,6-triisopropylbenzoic acid could not be hydrolyzed under a wide variety of basic conditions.[15] Reductive cleavage could be achieved, however, with lithium aluminum hydride in tetrahydrofuran or 1,2-dimethoxyethane. The latter solvent avoids the complication that can be introduced by the reduction of tetrahydrofuran to 1-butanol.[17] With this cleavage in hand, the use of ethyl 2,4,6-triisopropylbenzoate as an α-lithioethanol synthetic equivalent can be demonstrated.

Lithiations of the ethyl ester of **2** followed by addition of hexamethylphosphoric triamide prior to the electrophiles, acetone and 1-iodopentane, and reductive cleavage with lithium aluminum hydride provide 2-methyl-2,3-butanediol and 2-hexanol, respectively, in yields of 38% based on the starting ester (Scheme VI). We estimate an overall yield for this sequence based on starting alcohol would be on the order of 30%. While this yield is not high, it appears acceptable for a unique conversion.

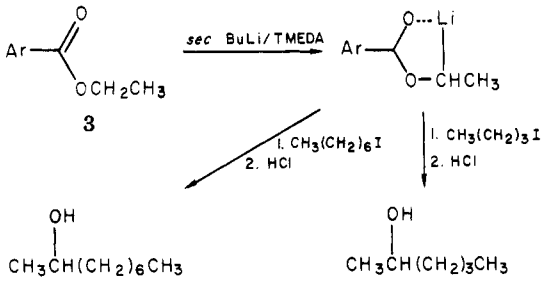
The substituted esters of **2** were stable to most acidic conditions; however, exposure of the cyclohexanol substituted ethyl and propyl esters **11** and **12** (Scheme VII) to sulfuric acid at 0 °C provided cyclohexyl methyl ketone and cyclohexyl propyl ketone characterized as 2,4-dinitrophenylhydrazones. In the case of the propyl ester conversion to the crude ketone was achieved in 47% yield, but the 2,4-dinitrophenylhydrazone was obtained in only 18% yield. Alternative methods of achieving reductive nucleophilic acylation of ketones are known.[18]

The preparation of the 2,6-bis(dimethylamino)-3,5-diisopropylbenzoates was carried out to provide a substituted ester which would be susceptible to acidic hydrolysis. The conception was that the 2,6-dimethylamino functions

(16) Schlosser, M. *J. Organometal. Chem.* **1967**, *8*, 9.

(17) Haubenstock, H.; Yang, N.-L. *J. Org. Chem.* **1978**, *43*, 1463.
(18) Martin, S. F. *Synthesis* **1979**, 633.

Scheme VIII



would provide hindrance to nucleophilic addition by the organolithium to carbonyl by either steric or electron-pair repulsions during metalation but that under acidic conditions protonation of the amine would provide assistance for hydrolytic cleavage of the ester. The electron pair repulsion–electron pair activation sequence should prove to be useful for a number of metalations. In fact, hydrolysis does proceed conveniently with 1:4 solutions of 10% aqueous hydrochloric acid–tetrahydrofuran at reflux for 24 h. In a model sequence for the synthetic use of this methodology, the ethyl ester of 3 was lithiated, treated with 1-iodobutane and 1-iodoheptane in separate experiments, and subjected to acidic hydrolysis to give 2-hexanol and 2-nonanol, isolated as the 3,5-dinitrobenzoates in yields of 68% and 38%, respectively (Scheme VIII). It is interesting that ethyl 2,6-bis(dimethylamino)benzoate does not possess sufficient steric hindrance to prevent nucleophilic addition to the carbonyl group (vide supra).[19] Apparently the isopropyl groups in the 3- and 5-positions are necessary to provide additional buttressing which twists the dimethylamino group appropriately for protection of the carbonyl.

In summary, the present work provides the key step and illustrative examples for the preparation of secondary α-lithio alcohol synthetic equivalents from primary alcohols. The unique step is the lithiation of a sterically hindered ester adjacent to oxygen; that result is consistent with the hypothesis that the lithiated intermediate is a dipole-stabilized carbanion. The extent of dipole stabilization, the role of the metal ion, the stereochemistry of the reaction, and the question of the kinetic and thermodynamic acidities in these systems are matters of continuing interest.

Experimental Section[20]

General Methods. Reactions involving organometallic reagents were performed in oven-dried glassware under a N_2 or Ar atomosphere. The molarity of organolithium reagents was determined by titration with *sec*-butyl alcohol in xylene with 1,10-phenanthroline as an indicator.[21] Tetrahydrofuran (THF) was dried by distillation from sodium benzophenone ketyl while dimethoxyethane was dried by distillation from lithium aluminum hydride. Tetramethylethylenediamine (TMEDA) was distilled from dry barium oxide or calcium hydride. The electrophilic reagents were generally dried by filtration through silica or by distillation. Other solvents and reagents from commercial sources were generally used without further purification.

2,4,6-Triisopropylbenzoic Acid. To a solution of 30 g (0.106 mol) of dry 2,4,6-triisopropylbromobenzene in 250 mL of THF stirred under N_2 at −78 °C was added 0.33 mol of *t*-BuLi in pentane.[22] The reaction mixture was stirred at −78 °C for 30 min. Dry carbon dioxide was bubbled through the reaction mixture for 30 min. The reaction mixture was stirred at −78 °C for 15 min and slowly warmed to room temperature, followed by removal of the solvent under reduced pressure. The residue was poured into 200 mL of 10% hydrochloric acid, and 12 N HCl was added until the pH of the solution was adjusted to 1. The aqueous phase was extracted with ether. The organic phase was dried ($CaSO_4$), and the solvent was removed under reduced pressure to give a brown oil which was crystallized from hexane to give 16.0 g (61%) of the acid as a white solid: mp 181–183 °C (lit.[23] mp 186–88 °C); ^{1}H NMR ($CDCl_3$) δ 1.17 (m, 18 H, $ArCH(CH_3)_2$), 3.03 (m, 3 H, $ArCH(CH_3)_2$), 7.03 (s, 2 H, ArH).

Ethyl 2,4,6-Triisopropylbenzoate. Method A. A solution of 5.0 g (20.1 mmol) of 2,4,6-triisopropylbenzoic acid and excess thionyl chloride was heated at reflux for 16 h, and the thionyl chloride was removed by distillation. To the residue were added 50 mL of ethanol and 2 mL of pyridine. The reaction mixture was heated at reflux for 21 h and cooled to room temperature. The solvent was removed under reduced pressure to give a mixture of a yellow oil and solid. The crude product was dissolved in ether and the insoluble salts were removed by filtration. The filtrate solvent was removed under reduced pressure and distilled in a Kugelrohr apparatus to give 4.9 g (88%) of the ethyl ester as a clear, colorless oil: bp 103 °C (0.1 mmHg); ^{1}H NMR ($CDCl_3$) δ 1.00–1.40 (m, 21 H, $ArCH(CH_3)$, OCH_2CH_3), 2.87 (m, 3 H, $ArCH(CH_3)_2$), 4.31 (q, J = 7 Hz, 2 H, OCH_2CH_3), 6.97 (s, 2 H, Ar H); IR (neat) 1735 cm^{-1} (C=O); mass spectrum (70 eV), m/e (relative intensity) 277 (7), 276 (31), 261 (14), 231 (56), 230 (100). Anal. ($C_{18}H_{28}O_2$) C, H.

Method B. To a solution of 30 g (0.106 mol) of dry 2,4,6-triisopropylbromobenzene in 270 mL of THF at −78 °C under N_2 was added 0.22 mol of *t*-BuLi in hexane. The reaction mixture was stirred at −78 °C for 30 min followed by the addition of 0.32 mol of diethyl carbonate. The reaction mixture was stirred at −78 °C for 30 min, and saturated ammonium chloride (NH_4Cl) solution was added. The reaction mixture was warmed to room temperature, and the layers were separated. The organic layer was washed with saturated NH_4Cl solution and dried, and the solvent was removed under reduced pressure to give an orange oil. The excess diethyl carbonate was removed via distillation with a Kugelrohr apparatus. The crude product was purified by medium-pressure liquid chromatography (MPLC) on silica with 1:99 ether/hexane as an eluent to give 13.5 g (46%) of the ethyl ester as a slightly yellow oil having analytical properties identical with those of the ester prepared by method A.

Method C.[24,25] A binary-phase solution of 2.0 g (8.06 mmol) of 2,4,6-triisopropylbenzoic acid in 50 mL of chloroform, 0.21 g of tetra-*n*-butylammonium hydrogen sulfate, 1.0 g of sodium hydroxide, 45 mL of water, and excess ethyl bromide was stirred at ambient temperature for 16 h. The organic layer was separated and dried, and the solvent was removed under reduced pressure. The residue was dissolved in ether, the insoluble salts were removed by filtration, and the filtrate was removed under reduced pressure to give 1.98 g (89%) of the ethyl ester as a clear, light yellow oil having spectral properties identical with those of the ester prepared by method A.

***n*-Propyl 2,4,6-Triisopropylbenzoate.** Method A was used to provide 2.32 g (72%) of the *n*-propyl ester as a clear, light yellow oil: ^{1}H NMR ($CDCl_3$) δ 0.98 (t, J = 7 H, 3 H, $O(CH_2)_2CH_3$), 1.24 (d, J = 6 H, 18 H, $ArCH(CH_3)_2$), 1.74 (m, 2 H, $OCH_2CH_2CH_3$), 2.86 (m, 3 H, $ArCH(CH_3)_2$), 4.22 (t, J = 6 Hz, 2 H, $OCH_2CH_2CH_3$), 7.00 (s, 2 H, Ar H); IR (neat) 1735 cm^{-1} (C=O); mass spectrum (70 eV), m/e (relative intensity) 291 (4), 290 (22), 247 (25), 233 (40), 231 (70), 230 (100). Anal. ($C_{19}H_{30}O_2$) C, H.

Method C was used with 1.0 g of the acid and 2 mL of 1-bromopropane to provide 0.98 g (84%) of the *n*-propyl ester having

(19) The steric bulk of the dimethylamino function is similar to that of the diisopropyl groups: Charton, M. *J. Org. Chem.* **1978**, *43*, 3995.

(20) The ^{1}H NMR chemical shifts are reported in δ units downfield from a tetramethylsilane internal standard. Mass spectra were obtained by J. Carter Cook and associates. Low-resolution electron-impact spectra were recorded by employing a Varian MAT CH-5 spectrometer, while field-desorption spectra were obtained with a Varian MAT 731 instrument. Melting points were determined on Thomas-Hoover capilliary melting point apparatus and are uncorrected. Boiling points were generally recorded during distillations and are also uncorrected. Elemental analyses were performed by Dr. J. Nemeth and associates.

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(25) Demlow, E. V. *Angew. Chem., Int. Ed. Engl.* **1974**, *13*, 170.

spectral properties identical with those of that provided by method A.

***n*-Octyl 2,4,6-Triisopropylbenzoate.** Method A was used with octyl alcohol to provide a brown oil which was distilled under vacuum by using a Kugelrohr apparatus to give 9.93 g (95%) of the octyl ester as a clear, colorless oil: bp 138 °C (0.2 torr); ^{1}H NMR ($CDCl_3$) δ 0.87 (m, 3 H, $O(CH_2)_7CH_3$), 1.20 (m, 28 H, $ArCH(CH_3)_2$, $O(CH_2)_2(CH_2)_5CH_3$), 1.72 (m, 2 H, OCH_2CH_2-$(CH_2)_5CH_3$), 4.26 (t, J = 6 Hz, 2 H, $OCH_2(CH_2)_6CH_3$), 7.0 (s, 2 H, Ar H); IR (neat) 1735 cm^{-1} (C=O); mass spectrum (70 eV), m/e (relative intensity) 36 (13), 248 (15), 247 (29), 233 (31), 231 (56), 230 (100). Anal. ($C_{24}H_{40}O_2$) C, H.

Method C was used with octyl bromide to provide a 62% yield of the octyl ester as a clear, light yellow oil having spectral properties identical with those of that prepared by method A.

Benzyl 2,4,6-triisopropylbenzoate was prepared by method A in 56% yield as a clear, colorless oil: ^{1}H NMR ($CDCl_3$) δ 1.23 (m, 18 H, $ArCH(CH_3)_2$), 2.83 (m, 3 H, $ArCH(CH_3)_2$), 5.33 (s, 2 H, OCH_2Ph), 7.00 (s, 2 H, Ar H), 7.40 (m, 5 H, Ar H); IR (neat) 1735 cm^{-1} (C=O). Anal. ($C_{24}H_{30}O_2$) C, H.

2′-Methoxyethyl 2,4,6-triisopropylbenzoate was prepared by method A and purified by MPLC to give an 80% yield of the ester as a clear, light yellow oil: ^{1}H NMR ($CDCl_3$) 1.23 (d, J = 8 Hz, 18 H, $ArCH(CH_3)_2$), 2.90 (m, 3 H, $ArCH(CH_3)_2$), 3.36 (s, 3 H, $OCH_2CH_2OCH_3$), 3.63 (m, 2 H, $OCH_2CH_2OCH_3$), 4.43 (m, 2 H, $OCH_2CH_2OCH_3$), 7.00 (s, 2 H, Ar H); IR (neat) 1735 cm^{-1} (C=O). Anal. ($C_{19}H_{30}O_3$) C, H.

2′-(Dimethylamino)ethyl 2,4,6-triisopropylbenzoate was prepared by method A to give an 83% yield of a clear, colorless oil: bp 110 °C (0.5 torr); ^{1}H NMR ($CDCl_3$) δ 1.27 (d, J = 7 Hz, 18 H, $ArCH(CH_3)_2$), 2.30 (s, 6 H, $OCH_2CH_2N(CH_3)_2$), 2.67 (t, J = 7 Hz, 2 H, $OCH_2CH_2N(CH_3)_2$), 2.87 (m, 3 H, $ArCH(CH_3)_2$), 4.40 (t, J = 7 Hz, 2 H, $OCH_2CH_2N(CH_3)_2$), 6.97 (s, 2 H, Ar H); IR (neat) 1735 cm^{-1} (C=O). Anal. ($C_{20}H_{33}NO_2$) C, H, N.

Isopropyl 2,4,6-triisopropylbenzoate was prepared by method A in 59% yield as a clear, light yellow oil: bp 96 °C (0.1 torr); ^{1}H NMR ($CDCl_3$) δ 1.30 (m, 24 H, $ArCH(CH_3)$, $OCH(CH_3)_2$), 2.90 (m, 3 H, $ArCH(CH_3)_2$), 5.25 (m, 1 H, $OCH(CH_3)_2$), 6.97 (s, 2 H, Ar H); IR (neat) 1735 cm^{-1} (C=O). Anal. ($C_{19}H_{30}O_2$) C, H.

Method C provided the same ester in 47% yield.

***n*-Hexadecyl 2,4,6-triisopropylbenzoate** was prepared by method C with excess *n*-hexadecyl bromide in 80% yield as a white solid: mp 37–39 °C; ^{1}H NMR ($CDCl_3$) 1.30 (m, 49 H, $ArCH(CH_3)_2$, $OCH_2(CH_2)_{14}CH_3$), 2.90 (m, 3 H, $ArCH_3$)), 4.30 (t, J = 7 Hz, 2 H, $OCH_2(CH_2)_{14}CH_3$), 7.03 (s, 2 H, Ar H); IR (neat) 1735 cm^{-1} (C=O). Anal. ($C_{32}H_{56}O_2$) C, H.

Allyl 2,4,6-triisopropylbenzoate was prepared by method C in 87% yield as a clear, light yellow oil: ^{1}H NMR ($CDCl_3$) δ 1.23 (d, J = 7 Hz, 18 H, $ArCH(CH_3)$), 2.78 (m, 3 H, $ArCH(CH_3)_2$), 4.76 (m, 2 H, OCH_2CHCH_2), 5.37 (m, 2 H, OCH_2CHCH_2), 5.93 (m, 1 H, OCH_2CHCH_2), 6.95 (s, 2 H, Ar H); IR (neat) 1735 cm^{-1} (C=O). Anal. ($C_{19}H_{28}O_2$) C, H.

2,6-Bis(dimethylamino)-3,5-diisopropylbenzoates were prepared as outlined in Scheme IX.

1,3-Diisopropyl-4,6-dinitrobenzene. To a solution of 57.5 mL (0.75 mol) of trifluoromethanesulfonic acid stirred in 600 mL of 1,2-dichloromethane (CH_2Cl_2) under N_2 at room temperature was slowly added 145 mL (0.325 mol) of fuming nitric acid. After the heterogeneous reaction mixture was stirred at room temperature for 15 min, 25 g (0.155 mol) of *m*-diisopropylbenzene (Aldrich) in 100 mL of CH_2Cl_2 was added slowly with ice-bath cooling to maintain the temperature between 25 and 35 °C. The reaction mixture was stirred at 25 °C for 1 h, followed by 0.5 h at 30–38 °C, and then cooled to room temperature. The reaction mixture was poured onto ice, and the layers were separated. The aqueous layer was extracted with ether. The organic layers were combined, washed with water, and dried ($CaSO_4$), and the solvent was removed under reduced pressure to give a brown oil. The oil was crystallized from 2-propanol to give 38.9 g (64%) of a clear, light yellow solid: mp 74.5–76 °C (lit.[26] mp 76.8–77.7 °C); ^{1}H NMR ($CDCl_3$) δ 1.36 (d, J = 7 Hz, 12 H, $ArCH(CH_3)_2$), 3.53 (m, 2 H, $ArCH(CH_3)_2$), 7.57 (s, 1 H, Ar H), 8.17 (s, 1 H, Ar H). Anal. ($C_{12}H_{16}N_2O_4$) C, H, N.

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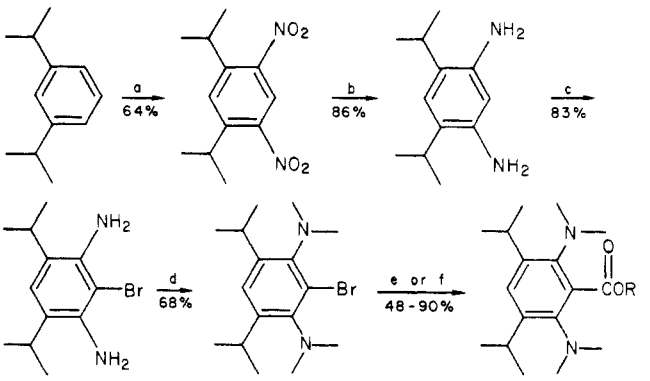
Scheme IX[a]



[a] (a) HNO_3, CF_3SO_3H; (b) 10% Pd/C, $NaBH_4$; (c) (C_5H_5N) Br_3, (C_5H_5N); (d) CH_2O, $NaB(CN)H_3$; (e) (1) *n*-BuLi, (2) CO_2, (3) RX, *n*-$Bu_4N^+HSO_4^-$, NaOH; (f) (1) *n*-BuLi, (2) RO(CO)Cl.

4,6-Diamino-1,3-diisopropylbenzene. A procedure similar to that of Brown et al. was used.[27] A suspension of 14.7 g (0.39 mol) of sodium borohydride in 150 mL of H_2O was added to a mixture of 1.0 g of 10% palladium on carbon in 150 mL of H_2O under N_2. To the reaction mixture was slowly added a solution of 23.3 g (0.09 mol) of 1,3-diisopropyl-4,6-dinitrobenzene. The reaction mixture was stirred 1 h at room temperature under N_2, the catalyst was removed via filtration, and the pH of the filtrate was adjusted to 7 and thereafter with stirring for 5 min to pH 11. The reaction mixture was extracted with ether. The organic layer was dried ($CaSO_4$) and the solvent removed under reduced pressure to give a brown oil which was crystallized from hexane to give 15.3 g (86%) of a light yellow solid: mp 72–74 °C (lit.[26] mp 72.6–73 °C); ^{1}H NMR ($CDCl_3$) δ 1.27 (d, J = 7 H, 12 H, $ArCH(CH_3)_2$), 2.96 (m, 3 H, $ArCH(CH_3)_2$), 3.43 (s, 4 H, $ArNH_2$), 6.03 (s, 1 H, Ar H), 6.83 (s, 1 H, Ar H).

2,6-Diamino-3,5-diisopropylbromobenzene. To a solution of 30 g (0.156 mol) of 4,6-diamino-1,3-diisopropylbenzene in 400 mL of THF was added 52 g (0.66 mol) of pyridine in 250 mL of THF. The reaction mixture was cooled to −70 °C under N_2. To the reaction mixture was added 131 g (0.33 mol) of pyridinium perbromide in 500 mL of THF. The reaction mixture was stirred at −70 °C for 2 h, a solution of 130 g of sodium bisulfite in 500 mL of H_2O was added, and the reaction mixture was warmed to room temperature. The aqueous layer was separated. The organic layer was washed with aqueous sodium bisulfite. The aqueous layers were combined and washed with ether, the organic layers were combined and dried ($CaSO_4$), and the solvent was removed under reduced pressure to give 35 g (83%) of a brown oil with the expected spectral properties. This material was used without further purification.

2,6-Bis(dimethylamino)-3,5-diisopropylbromobenzene. To a solution of 7.3 g (0.027 mol) of bromo-2,6-diamino-3,5-diisopropylbenzene stirrred at room temperature in 280 mL of acetonitrile was added 80 mL of formaldehyde solution (37% in H_2O), followed by 14 g of sodium cyanoborohydride.[28] The reaction mixture was stirred 15 min, and the pH of the reaction mixture was carefully adjusted with acetic acid to 5–6 and maintained there for 2 h. The reaction mixture was concentrated under reduced pressure, and the residue was dissolved in 150 mL of 2 N NaOH and extracted with ether. The ether layer was dried ($CaSO_4$) and the solvent removed under reduced pressure to give a yellow solid. The solid was recrystallized from acetone to give 5.95 g (68%) of a white solid: mp 152–153.5 °C; ^{1}H NMR ($CDCl_3$) δ 1.17 (d, J = 7 Hz, 12 H, $ArCH(CH_3)_2$), 2.80 (s, 12 H, $ArN(CH_3)_2$), 3.37 (m, 2 H, $ArCH(CH_3)_2$), 6.97 (s, 1 H, Ar H). Anal. ($C_{16}H_{27}BrN_2$) C, H, N.

2,6-Bis(dimethylamino)-3,5-diisopropylbenzoic Acid. To a solution of 3.28 mmol of *n*-BuLi in 20 mL of THF stirred at −78 °C under N_2 was added a solution of 0.894 g (2.73 mmol) of

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(28) Borch, R. F.; Hassid, A. I. *J. Org. Chem.* **1972**, *37*, 1673.

2,6-bis(dimethylamino)-3,5-diisopropylbromobenzene in 3 mL of THF. The reaction mixture stirred at −78 °C for 20 min followed by the addition of CO_2 (gas) to the solution for 0.5 h. The reaction mixture was warmed to room temperature, and ether was added. The organic mixture was washed with saturated aqueous NH_4Cl, maintaining the pH of the aqueous layer at 5. The organic layer was dried ($CaSO_4$) and the solvent removed under reduced pressure to give a solid. The solid was recrystallized from acetone to give 0.71 g (90%) of the acid as a white solid: mp 237.5–239 °C dec; ^1H NMR ($(CD_3)_2CO$) 1.20 (J = 7 Hz, 12 H, $ArCH(CH_3)_2$), 2.70 (s, 12 H, $ArN(CH_3)_2$), 3.30 (m, 2 H, $ArCH(CH_3)_2$), 7.22 (s, 1 H, Ar H); IR (mull) 1705 cm^{-1} (C=O); mass spectrum (70 eV), m/e (relative intensity) 292 (44), 275 (8), 259 (12), 233 (100). Anal. ($C_{17}H_{28}N_2O_2$) C, H, N.

Ethyl 2,6-Bis(dimethylamino)-3,5-diisopropylbenzoate. Method A. To a stirred solution of 1.05 g (3.20 mmol) of the acid in 20 mL of THF at −78 °C under Ar was added 3.80 mmol of n-BuLi in hexane. The reaction mixture stirred 15 min at −78 °C, followed by the addition of 3 mL of ethyl chloroformate. The reaction mixture was warmed to room temperature, ether was added, the reaction mixture was washed with aqueous saturated NH_4Cl solution and dried ($CaSO_4$), and the solvent was removed under reduced pressure to give an orange solid. The crude product was purified by MPLC on silica with 2.5:97.5 ether/hexane as an eluent to give 0.79 g (74%) of a white solid: mp 102–104 °C; ^1H NMR ($CDCl_3$) δ 1.18 (d, J = 6 Hz, 12 H, $ArCH(CH_3)_2$), 1.36 (t, J = 8 Hz, 3 H, OCH_2CH_3), 2.73 (s, 12 H, $ArN(CH_3)_2$), 3.23 (m, 2 H, $ArCH(CH_3)_2$), 4.28 (q, J = 7 Hz, 2 H, OCH_2CH_3), 7.05 (s, 1 H, Ar H). Anal. ($C_{19}H_{32}N_2O_2$) C, H, N.

Method B. To a stirred solution of 1.25 g (4.27 mmol) of the solid and 3 mL of ethyl bromide in 35 mL of chloroform was added a solution of 0.2 g of tetra-n-butylammonium hydrogen sulfate and 0.35 g of NaOH in 25 mL of H_2O. The reaction mixture was stirred for 3 h, the organic and aqueous phases were separated, the organic layer was washed with base and dried ($CaSO_4$), and the solvent was removed under reduced pressure. The residue was dissolved in ether, and insoluble salts were removed by filtration. The filtrate solvent was removed under reduced pressure to give 1.15 g of a light tan solid. The crude product was dissolved in 95:5 hexane/ether and filtered through silica gel. The filtrate solvent was removed under reduced pressure to give 1.05 g (77%) of the ethyl ester as a white solid (mp 102-104 °C) having spectral properties identical with those of the material prepared by method A.

Isopropyl 2,6-bis(dimethylamino)-3,5-diisopropylbenzoate was prepared according to the procedure of method A in 48% yield as a white solid: mp 108–109.5 °C; ^1H NMR ($CDCl_3$) δ 1.20 (d, J = 7 Hz, 12 H, $ArCH(CH_3)_2$), 1.33 (d, J = 7 Hz, 6 H, $OCH(CH_3)_2$), 2.73 (s, 12 H, $ArN(CH_3)_2$), 3.23 (m, 2 H, $ArCH(CH_3)_2$), 5.23 (m, 1 H, $OCH(CH_3)_2$), 7.00 (s, 1 H, Ar H); IR (mull) 1735 cm^{-1} (C=O). Anal. ($C_{20}H_{34}N_2O_2$) C, H, N.

Methyl 2,6-bis(dimethylamino)-3,5-diisopropylbenzoate was prepared according to method B in 90% yield as a white solid: mp 134–136 °C; ^1H NMR ($CDCl_3$) δ 1.17 (d, J = 7 Hz, 12 H, $ArCH(CH_3)_2$), 2.73 (s, 12 H, $ArN(CH_3)_2$), 3.23 (m, 2 H, $ArCH(CH_3)_2$), 3.83 (s, 3 H, OCH_3), 7.00 (s, 1 H, Ar H); IR (mull) 1735 cm^{-1} (C=O); mass spectrum (70 eV), m/e (relative intensity) 307 (16), 306 (79), 291 (18), 275 (100), 260 (17), 259 (62). Anal. ($C_{18}H_{30}N_2O_2$) C, H, N.

n-Pentyl 2,6-bis(dimethylamino)-3,5-diisopropylbenzoate was preapared according to method B in 79% yield as a white solid: mp 68–69.5 °C; ^1H NMR ($CDCl_3$) δ 0.90 (m, 3 H, $O(CH_2)_4CH_3$), 1.10–1.93 (m, 18 H, $OCH_2(CH_2)_3CH_3$, $ArCH(CH_3)_2$), 2.70 (s, 12 H, $ArN(CH_3)_2$), 3.17 (m, 2 H, $ArCH(CH_3)_2$), 4.23 (t, J = 6 Hz, 2 H, $OCH_2(CH_2)_3CH_3$), 7.00 (s, 1 H, Ar H); IR (mull) 1750 cm^{-1} (C=O); mass spectrum (70 eV), m/e (relative intensity) 363 (9), 362 (38), 291 (18), 275 (100), 259 (41). Anal. ($C_{22}H_{38}N_2O_2$) C, H, N.

Reaction of 2 (R = CH_3) with *sec*-BuLi/TMEDA Followed by Addition of Deuteriomethanol. General Procedure for Lithiation. To a solution of 1:1 *sec*-BuLi/TMEDA (4.12 mmol) in 10–20 mL of THF at −78 °C was added a solution of 0.286 g (1.04 mmol) of **2** (R = CH_3) in 1–2 mL of THF with stirring. The reaction mixture was stirred at −78 °C for 6 h followed by the addition of 1 mL of methanol-d_4 at −78 °C. The reaction mixture was warmed to room temperature. Ether was added, the organic phase was washed with saturated NH_4Cl solution and dried ($CaSO_4$), and the solvent was removed under reduced pressure to give a clear light yellow oil, which was subjected to preparative TLC on silica with 5:95 ether/pentane as an eluent to give 0.2 g (70%) of a clear, colorless oil whose mass spectral analysis indicated 95% d_1 incorporation: ^1H NMR ($CDCl_3$) δ 1.10–1.40 (m, 21 H, $ArCH(CH_3)_2$, $OCH(D)CH_3$), 2.87 (m, 3 H, $ArCH(CH_3)_2$), 4.27 (m, 1 H, $OCH(D)CH_3$), 6.97 (s, 2 H, Ar H); IR (neat) 1735 cm^{-1} (C=O).

Reaction of 2 (R = CH_3) with *sec*-BuLi/TMEDA Followed by Addition of Allyl Bromide. According to the general procedure, 4.91 mmol of *sec*-BuLi/TMEDA was treated with 0.339 g (1.23 mmol) of ester followed by 2 mL of allyl bromide to give a yellow oil. The crude product was purified by MPLC on silica with 2:98 ethyl acetate/pentane as an eluent to give 0.24 g (62%) of a clear, colorless oil: ^1H NMR ($CDCl_3$) δ 1.27 (d, J = 6 Hz, 18 H, $ArCH(CH_3)_2$), 1.36 (t, J = 6 Hz, 3 H, $OCH(CH_2CHCH_2)CH_3$), 2.43 (m, 2 H, $OCH(CH_2CHCH_2)CH_3$), 2.87 (m, 3 H, $ArCH(CH_3)_2$), 5.10 (m, 3 H, $OCH(CH_2CHCH_2)CH_3$), 5.67 (m, 1 H, $OCH(CH_2CHCH_2)CH_3$), 6.97 (s, 1 H, Ar H); IR (neat) 1735 cm^{-1} (C=O). Anal. ($C_{21}H_{32}O_2$) C, H.

Reaction of 2 (R = CH_3) with *sec*-BuLi/TMEDA Followed by Addition of 1-Iodobutane. According to the general procedure, 3.68 mmol of *sec*-BuLi/TMEDA was treated with 0.254 g (0.92 mmol) of ester followed by 2 mL of 1-iodobutane to give a yellow oil. The crude product was purified by MPLC on silica with 1:99 ether/hexane as an eluent to give 0.142 g (50%) of a clear, colorless oil: ^1H NMR ($CDCl_3$) δ 0.90 (m, 3 H, $OCH((CH_2)_3CH_3)CH_3$), 1.20 (d, J = 8 Hz, 18 H, $ArCH(CH_3)_2$), 1.20–1.67 (m, 9 H, $OCH((CH_2)_3CH_3)CH_3$), 2.87 (m, 3 H, $ArCH(CH_3)_2$), 5.16 (m, 1 H, $OCH((CH_2)_3CH_3)CH_3$), 6.93 (s, 2 H, Ar H); IR (neat) 1735 cm^{-1} (C=O). Anal. ($C_{22}H_{36}O_2$) C, H.

Reaction of 2 (R = CH_3) with *sec*-BuLi/TMEDA Followed by Addition of Chlorotri-n-butyltin. According to the general procedure, 28.38 mmol of *sec*-BuLi/TMEDA was treated with 3.133 g (11.35 mmol) of ester followed by excess chlorotri-n-butyltin to give a clear oil. The crude product was purified by distillation to give 3.40 g (53%) of a clear, colorless oil: ^1H NMR ($CDCl_3$) δ 0.67–1.67 (m, 48 H, $ArCH(CH_3)_2$, $OCH(Sn((CH_2)_3CH_3)_3)CH_3$), 2.84 (m, 3 H, $ArCH(CH_3)_2$), 5.17 (q, J = 7 Hz, 1 H, $OCH(Sn((CH_2)_3CH_3)_3)CH_3$), 6.93 (s, 2 H, Ar H); IR (neat) 1710 cm^{-1} (C=O). Anal. ($C_{30}H_{54}O_2Sn$) C, H, Sn.

Reaction of 2 (R = CH_3) with *sec*-BuLi/TMEDA Followed by the Addition of Chlorotrimethylsilane. According to the general procedure, 10.24 mmol of *sec*-BuLi/TMEDA was treated with 0.702 g (2.54 mmol) of ester followed by the addition of chlorotrimethylsilane to give a yellow oil. The oil was purified by preparative TLC on silica with 20:80 ether/pentane as an eluent to give 0.56 g (64%) of a clear, colorless oil: ^1H NMR ($CDCl_3$) δ 0.10 (s, 9 H, $OCH(Si(CH_3)_3)CH_3$), 1.10–1.47 (m, 21 H, $ArCH(CH_3)_2$, $OCH(Si(CH_3)_3)CH_3$), 2.87 (m, 3 H, $ArCH(CH_3)$), 5.00 (q, J = 8 Hz, 1 H, $OCH(Si(CH_3)_3)CH_3$), 6.97 (s, 2 H, Ar H); IR (neat) 1735 cm^{-1}. Anal. ($C_{21}H_{36}O_2Si$) C, H.

Reaction of 2 (R = CH_3) with *sec*-BuLi/TMEDA Followed by Addition of Acetone. According to the general procedure, 3.67 mmol of *sec*-BuLi/TMEDA was treated with 0.253 g (0.92 mmol) of ester followed by 1 mL of acetone to give a yellow oil. The crude product was subjected to preparative TLC on silica with 40:60 ether/hexane as an eluent to give 0.21 g (67%) of a clear, colorless oil: ^1H NMR ($CDCl_3$) δ 1.26 (m, 27 H, $ArCH(CH_3)_2$, $OCH(C(OH)(CH_3)_2)CH$), 1.83 (m, 1 H, $OCH(C(OH)(CH_3)_2)CH_3$), 2.90 (m, 3 H, $ArCH(CH_3)_2$), 5.00 (q, J = 6 Hz, 1 H, $OCH(C(OH)(CH_3)_2)CH_3$), 7.00 (s, 2 H, ArH); IR (neat) 1735 cm^{-1} (C=O). Anal. ($C_{21}H_{34}O_3$) C, H.

Reaction of 2 (R = CH_3) with *sec*-BuLi/TMEDA Followed by Addition of Acetone-d_6. According to the general procedure, 4.7 mmol of *sec*-BuLi/TMEDA was treated with 0.487 g (1.77 mmol) of ester followed by the addition of excess acetone-d_6 to give an oil. The crude product was subjected to preparative TLC on silica with 20:80 ether/pentane as an eluent to give 0.40 g (67%) of a clear, colorless oil: ^1H NMR ($CDCl_3$) δ 1.10–1.40 (m, 21 H, $ArCH(CH_3)_2$, $OCH(C(OH)(CD_3)_2)CH_3$), 2.87 (m, 3 H, $ArCH(CH_3)_2$), 5.00 (q, J = 7 Hz, 1 H, $OCH(C(OH)(CD_3)_2)CH_3$), 7.00 (s, 2 H, Ar H).

Reaction of 2 (R = CH_3) with *sec*-BuLi/TMEDA Followed by Addition of Cyclohexanone. According to the general

procedure, 5.28 mmol of *sec*-BuLi/TMEDA was treated with 0.420 g (1.52 mmol) of ester followed by the addition of excess cyclohexanone to give a clear, yellow oil. The oil was purified by preparative TLC on silica with 20:80 ether/pentane as the eluent to give 0.176 g (31%) of a clear, colorless oil: ^{1}H NMR ($CDCl_3$) δ 1.23 (d, J = 7 Hz, 18 H, $ArCH(CH_3)_2$), 1.30 (t, J = 7 Hz, 3 H, $OCH(C_6H_{10}OH)CH_3$), 1.53 (m, 10 H, $OCH(C_6H_{10}OH)CH_3$), 2.90 (m, 3 H, $ArCH(CH_3)_2$), 5.03 (q, 1 H, J = 7 Hz, $OCH(C_6H_{10}OH)CH_3$), 7.00 (s, 2 H, Ar H); IR (neat) 3400 (OH), 1715 cm^{-1} (C=O). Anal. ($C_{20}H_{38}O_3$) C, H.

Reaction of 1′-(Tri-*n*-butylstannyl)ethyl 2,4,6-Triisopropylbenzoate with MeLi Followed by Addition of Cyclohexanone. To a solution of 2.70 g (4.78 mmol) of the ester in 30 mL of THF at −78 °C under Ar was added 1.25 equiv of methyllithium–lithium bromide in ether. The reaction was stirred for 0.5 h followed by the addition of excess cyclohexanone at −78 °C. The reaction mixture was warmed to room temperature. Ether was added, the organic phase was washed with saturated NH_4Cl solution and dried ($CaSO_4$), and the solvent was removed under reduced pressure to give a clear, colorless oil. The oil was purified by distillation with a Kugelrohr apparatus to give 1.42 g (76%) of a clear, colorless oil which had spectral properties identical with those of the material previously prepared.

Reaction of 2 (R = CH_3) with *sec*-BuLi/TMEDA Followed by Addition of Acetaldehyde. According to the general procedure, 2.11 mmol of *sec*-BuLi/TMEDA was treated with 0.146 g (0.53 mmol) of ester followed by excess acetaldehyde to give a clear, yellow oil. The crude product was purified by MPLC on silica with 1:99 ether/hexane as an eluent to give an oil which was further purified by preparative TLC on silica with 30:70 ether/hexane as an eluent to give 0.1094 g (65%) of a clear, colorless oil: ^{1}H NMR ($CDCl_3$) δ 1.23 (d, J = 7 Hz, 21 H, $ArCH(CH_3)_2$, $OCH(CH(OH)CH_3)CH_3$), 1.37 (d, J = 3 Hz, 3 H, $OCH(CH(OH)CH_3)CH_3$), 1.77 (m, 1 H, $OCH(CH(OH)CH_3)CH_3$), 2.90 (m, 3 H, $ArCH(CH_3)_2$), 3.90 (m, 1 H, $OCH(CH(OH)CH_3)CH_3$), 5.10 (m, 1 H, $OCH(CH(OH)CH_3)CH_3$), 6.97 (s, 2 H, Ar H); IR (neat) 1735 (C=O), 3460 (br, OH) cm^{-1}. Anal. ($C_{20}H_{32}O_3$) C, H.

Reaction of 2 (R = CH_3) with *sec*-BuLi/TMEDA Followed by Addition of *N,N*-Dimethylmethyleneammonium Iodide. According to the general procedure, 3.18 mmol of *sec*-BuLi/TMEDA was treated with 0.219 g (0.79 mmol) of ester followed by the addition of *N,N*-dimethylmethyleneammonium iodide[29] to give a clear, light yellow oil. The crude product was purified via MPLC on alumina with 5:95 ether/hexane to give 0.11 g (42%) of a clear, light yellow oil: ^{1}H NMR ($CDCl_3$) δ 1.27 (d, J = 7 Hz, 18 H, $ArCH(CH_3)_2$), 1.36 (d, J = 5 Hz, 3 H, $OCH(CH_2N(CH_3)_2)CH_3$), 2.30 (s, 6 H, $OCH(CH_2N(CH_3)_2CH_3$), 2.46 (m, 2 H, $OCH(CH_2N(CH_3)_2CH_3$), 3.00 (m, 3 H, $ArCH(CH_3)_2$), 5.36 (m, 1 H, $OCH(CH_2N(CH_3)_2CH_3$), 7.00 (s, 2 H, Ar H); IR (neat) 1735 cm^{-1} (C=O). Anal. ($C_{21}H_{35}NO_2$) C, H.

Reaction of 1′-(Tri-*n*-butylstannyl)ethyl 2,4,6-Triisopropylbenzoate with MeLi Followed by Addition of 2-Cyclohexen-1-one. To a solution of 0.223 g (0.39 mmol) of the ester in 15 mL of THF at −78 °C under Ar was added 1.25 equiv of MeLi–LiBr in ether. The reaction mixture stirred at −78 °C for 0.5 h followed by the addition of excess 2-cyclohexen-1-one at −78 °C. The reaction mixture was warmed to room temperature. Ether was added, the organic phase was washed with saturated NH_4Cl solution and dried ($CaSO_4$), and the solvent was removed under reduced pressure to give a clear, colorless oil. The oil was purified by distillation with a Kugelrohr apparatus to give 0.085 g (59%) of a clear, colorless oil: ^{1}H NMR ($CDCl_3$) δ 1.30 (d, J = 7 Hz, 18 H, $ArCH(CH_3)_2$), 1.36 (d, J = 7 Hz, 3 H, $OCH(C(OH)((CH_2)_3CHCH))CH_3$), 1.73 (m, 7 H, $OCH(C(OH)((CH_2)_3CHCH))CH_3$), 2.90 (m, 3 H, $ArCH(CH_3)_2$), 5.13 (m, 1 H, $OCH(C(OH)((CH_2)_6CHCH))CH_3$), 5.73 (m, 2 H, $OCH(C(OH)((CH_2)_3CHCH))CH_3$), 7.00 (s, 2 H, Ar H); IR (neat) 1735 cm^{-1} (C=O). Anal. ($C_{24}H_{36}O_3$) C, H.

2-Heptanol from Reaction of 2 (R = CH_3) with *sec*-BuLi/TMEDA Followed by Addition of 1-Iodopentane and Treatment with Lithium Aluminum Hydride. To a solution of 1:1 *sec*-BuLi/TMEDA (25.3 mmol) in THF stirred at −78 °C under Ar was added a solution of 3.98 g (14.4 mmol) of the ester in THF. After the reaction mixture was stirred at −78 °C for 6 h, 4 mL of HMPA was added, followed by 20 mL of 1-iodopentane. The reaction mixture was stirred at −78 °C for 20 min and then warmed to room temperature. Ether was added, the organic phase was washed with aqueous saturated NH_4Cl, and the solvent was removed under reduced pressure. The residue was dissolved in ether and washed with 10% HCl followed by 10% NaOH. The organic layer was dried ($CaSO_4$) and the solvent removed under reduced pressure to give 4.8 g of a clear, orange oil. A heterogeneous mixture of this oil and 5.0 g (0.13 mol) of $LiAlH_4$ in 75 mL of dimethoxyethane was heated at reflux for 2.5 h. The heterogeneous reaction mixture was cooled to room temperature and treated with a minimal amount of H_2O. The insoluble salts were removed by filtration and washed with ether. The filtrates were combined and dried ($MgSO_4$), and the solvent was removed under reduced pressure to give a clear, yellow oil which was distilled at atmospheric pressure to afford 0.64 g (38%) of 2-heptanol.

2-Methyl-2,3-butanediol from Reaction of 2 (R = CH_3) with *sec*-BuLi/TMEDA Followed by Addition of Acetone and Treatment with Lithium Aluminum Hydride. The above procedure for the preparation of 2-heptanol was followed, except that THF was the reduction solvent, and gave 38% of 2-methyl-2,3-butanediol as a clear, colorless oil.

Reaction of 2 (R = CH_2CH_3) with *sec*-BuLi/TMEDA Followed by Addition of Methanol-d_4. According to the general procedure, 3.88 mmol of *sec*-BuLi/TMEDA was treated with 0.281 g (0.97 mmol) of ester followed by the addition of methanol-d_4. The crude product was purified by preparative TLC on silica with 3:97 ether/pentane as an eluent to give 0.18 g (64%) of a clear, colorless oil. Mass spectral analysis indicated 95% d_1 incorporation: ^{1}H NMR ($CDCl_3$) δ 0.98 (t, J = 7 Hz, 3 H, $OCH(D)CH_2CH_3$), 1.24 (d, J = 6 Hz, 18 H, $ArCH(CH_3)_2$), 1.74 (m, 2 H, $OCH(D)CH_2CH_3$), 2.86 (m, 3 H, $ArCH(CH_3)$), 4.20 (m, 1 H, $OCH(D)CH_2CH_3$), 7.00 (s, 2 H, Ar H); IR (neat) 1735 cm^{-1} (C=O).

Reaction of 2 (R = CH_2CH_3) with *sec*-BuLi/TMEDA Followed by Addition of Acetone. According to the general procedure, 4.05 mmol of *sec*-BuLi/TMEDA was treated with 0.294 g (1.01 mmol) of ester, followed by treatment with 3 mL of acetone. The crude product was purified by preparative TLC on silica with 20:80 ether/pentane as an eluent to give 0.18 g (51%) of a clear, colorless oil: ^{1}H NMR ($CDCl_3$) δ 1.23 (m, 27 H, $ArCH(CH_3)_2$, $OCH(C(OH)(CH_3)_2)CH_2CH_3$), 1.70 (m, 2 H, $OCH(C(OH)(CH_3)_2)CH_2CH_3$), 1.97 (m, 1 H, $OCH(C(OH)(CH_3)_2)CH_2CH_3$), 3.03 (m, 3 H, $ArCH(CH_3)_2$), 4.96 (m, 1 H, $OCH(C(OH)(CH_3)_2)CH_2CH_3$), 7.00 (s, 2 H, Ar H); IR (neat) 1735 cm^{-1} (C=O). Anal. ($C_{22}H_{36}O_2$) C, H.

Reaction of 2 (R = CH_2CH_3) with *sec*-BuLi/TMEDA Followed by Addition of Allyl Bromide. According to the general procedure, 3.24 mmol of *sec*-BuLi/TMEDA was treated with 0.235 g (0.81 mmol) of ester, followed by addition of 2 mL of allyl bromide to give an oil. The crude product was purified by MPLC on silica with 0.5:99.5 ether/hexane as an eluent to give 0.173 g (67%) of a clear, slightly yellow oil: ^{1}H NMR ($CDCl_3$) δ 0.90 (m, 3 H, $OCH(CH_2CHCH_2)CH_2CH_3$), 1.27 (d, J = 7 Hz, 18 H, $ArCH(CH_3)_2$), 1.70 (m, 2 H, $OCH(CH_2CHCH_2)CH_2CH_3$), 2.47 (m, 2 H, $OCH(CH_2CHCH_2)CH_2CH_3$), 2.93 (m, 3 H, $ArCH(CH_3)_2$), 5.17 (m, 3 H, $OCH(CH_2CHCH_2)CH_2CH_3$), 5.83 (m, 1 H, $OCH(CH_2CHCH_2)CH_2CH_3$), 7.00 (s, 2 H, Ar H); IR (neat) 1735 cm^{-1} (C=O). Anal. ($C_{22}H_{34}O_2$) C, H.

Reaction of 2 (R = $(CH_2)_6CH_3$) with *sec*-BuLi/TMEDA Followed by Addition of Methanol-d_4. According to the general procedure, 3.78 mmol of *sec*-BuLi/TMEDA was treated with 0.341 g (0.95 mmol) of ester, followed by addition of methanol-d_4. The crude product was purified by preparative TLC on silica with 5:95 ether/pentane as an eluent to give 0.25 g (73%) of a clear, colorless oil. Mass spectral analysis indicated 93% d_1 incorporation: ^{1}H NMR ($CDCl_3$) δ 0.87 (m, 3 H, $OCH(D)(CH_2)_6CH_3$), 1.20 (m, 30 H, $ArCH(CH_3)_2$, $OCH(D)(CH_2)_6CH_3$), 2.83 (m, 3 H, $ArCH(CH_3)_2$), 4.25 (m, 1 H, $OCH(D)(CH_2)_6CH_3$), 7.00 (s, 2 H, Ar H).

Reaction of 2 (R = $(CH_2)_6CH_3$) with *sec*-BuLi/TMEDA Followed by the Addition of Allyl Bromide. According to the general procedure, 3.84 mmol of *sec*-BuLi/TMEDA was treated with 0.346 g (0.96 mmol) of ester, followed by the addition of 2 mL of allyl bromide. The crude product was purified by MPLC

(29) Schreiber, J.; Maag, H.; Hashimoto, N.; Eschenmoser, A. *Angew. Chem., Int. Ed. Engl.* **1971**, *10*, 330.

on silica with 0.5:99.5 ether/hexane as an eluent to give 0.247 g (64%) of a clear, colorless oil: ^{1}H NMR ($CDCl_3$) δ 0.87 (m, 3 H, $OCH(CH_2CHCH_2)(CH_2)_6CH_3$), 1.20 (m, 30 H, $ArCH(CH_3)_2$, $OCH(CH_2CHCH_2)(CH_2)_6CH_3$), 2.40 (m, 2 H, $OCH(CH_2CHCH_2)(CH_2)_6CH_3$), 2,97 (m, 3 H, $ArCH(CH_3)_2$), 5.13 (m, 3 H, $OCH(CH_2CHCH_2)(CH_2)_6CH_3$), 5.76 (m, 1 H, $OCH(CH_2CHCH_2)(CH_2)_6CH_3$), 7.00 (s, 2 H, Ar H); IR (neat) 1735 cm^{-1} (C=O). Anal. ($C_{27}H_{44}O_2$) C, H.

Reaction of 2 (R = $(CH_2)_6CH_3$) with *sec*-BuLi/TMEDA Followed by Addition of Chlorotrimethylsilane. To a solution of 1:1 *sec*-BuLi/TMEDA (22.82 mmol) in 25 mL of THF at −78 °C was added a solution of 2.00 g (5.71 mmol) of ester. The reaction mixture was stirred at −50 °C for 0.5 h. A catalytic amount of cuprous iodide was added at −78 °C, the reaction mixture was stirred 5 min at −78 °C, and excess chlorotrimethylsilane was added, followed by warming to ambient temperature. Ether was added to the reaction mixture, the mixture was washed with saturated NH_4Cl solution and dried ($CaSO_4$), and the solvent was removed under reduced pressure to give a yellow oil. The oil was purified by MPLC on silica with hexane as an eluent to give 1.74 g (72%) of a clear, colorless oil: ^{1}H NMR ($CDCl_3$) δ 0.10 (m, 9 H, $OCH(Si(CH_3)_3)(CH_2)_6CH_3$), 0.83 (m, 3 H, $OCH(Si(CH_3)_3)(CH_2)_6CH_3$), 1.27 (m, 30 H, $ArCH(CH_3)_2$, $OCH(Si(CH_3)_3)(CH_2)_6CH_3$), 2.90 (m, 3 H, $ArCH(CH_3)_2$), 5.00 (t, 1 H, $OCH(Si(CH_3)_2)(CH_2)_6CH_3$), 6.93 (s, 2 H, Ar H); IR (neat) 1725 cm^{-1} (C=O). Anal. ($C_{12}H_{48}O_2Si$) C, H.

Reaction of 2 (R = $(CH_2)_6CH_3$) with *sec*-BuLi/TMEDA Followed by Addition of Acetone. According to the general procedure, 2.96 mmol of *sec*-BuLi/TMEDA was treated with 0.265 g (0.74 mmol) of ester, followed by the addition of 2 mL of acetone. The crude product was purified by preparative TLC on silica with 35:65 ether/hexane as an eluent to give 0.163 g (52%) of a clear, light yellow oil: ^{1}H NMR ($CDCl_3$) δ 0.87 (m, 3 H, $OCH(C(OH)(CH_3)_2)(CH_2)_6CH_3$), 1.27 (m, 34 H, $ArCH(CH_3)_2$,$OCH(C(OH)(CH_3)_2)CH_2(CH_2)_5CH_3$), 1.60 (m, 2 H, $OCH(C(OH)(CH_3)_2)CH_2(CH_2)_5CH_3$), 2.93 (m, 3 H, $ArCH(CH_3)_2$), 5.03 (m, 1 H, $OCH(C(OH)(CH_3)_2)(CH_2)_6CH_3$), 7.00 (s, 2 H, Ar H); IR (neat) 1735 cm^{-1} (C=O); mass spectrum, *m/e* (relative intensity) 418 (5), 231 (100). Anal. ($C_{27}H_{46}O_3$) C, H.

Reaction of 2 (R = C_6H_5) with *sec*-BuLi/TMEDA Followed by Addition of Methyl Iodide. To a solution of 1:1 *sec*-BuLi/TMEDA (1.89 mmol) in 15 mL of THF at −78 °C was added a solution of 0.160 g (0.47 mmol) of ester in 2 mL of THF. The reaction mixture was stirred at −78 °C for 1 h followed by the addition of 1 mL of methyl iodide. The reaction mixture was warmed to ambient temperature, and ether was added. The organic phase was washed with saturated NH_4Cl solution and dried ($CaSO_4$), and the solvent was removed under reduced pressure to give a clear, yellow oil. The oil was purified by preparative TLC on silica with 30:70 ether/hexane as an eluent to give 0.140 g (85%) of a clear, light yellow oil: ^{1}H NMR ($CDCl_3$) δ 1.20 (m, 18 H, $ArCH(CH_3)_2$), 1.60 (d, J = 3 Hz, 3 H, $OCH(CH_3)(C_6H_5)$), 2.82 (m, 3 H, $ArCH(CH_3)_2$), 6.16 (q, J = 7 Hz, 1 H, $OCH(CH_3)(C_6H_5)$), 6.97 (s, 2 H, Ar H), 7.33 (m, 5 H, $OCH(CH_3)(C_6H_5)$); IR 1735 cm^{-1} (C=O). Anal. ($C_{24}H_{32}O_2$) C, H.

Reaction of 1′-Methylbenzyl 2,4,6-Triisopropylbenzoate with *sec*-BuLi/TMEDA Followed by Addition of Methyl Iodide. According to the general procedure for the preparation of 2 (R = C_6H_5), 0.97 mmol of *sec*-BuLi/TMEDA was treated with 0.086 g (0.24 mmol) of ester for 1 h followed by 1 mL of methyl iodide to give a yellow oil. The crude product was subjected to preparative TLC on silica with 30:70 ether/hexane as an eluent to give 0.061 g (69%) of a clear, colorless oil: ^{1}H NMR ($CDCl_3$) δ 1.23 (d, J = 7 Hz, 18 H, $ArCH(CH_3)_2$), 1.93 (s, 6 H, $OC(CH_3)_2(C_6H_5)$), 2.93 (m, 3 H, $ArCH(CH_3)_2$), 6.96 (s, 2 H, Ar H), 7.36 (m, 5 H, $OC(CH_3)_2(C_6H_5)$); IR (neat) 1735 cm^{-1} (C=O). Anal. ($C_{25}H_{34}O_2$) C, H.

Reaction of 2 (R = $CH_2N(CH_3)_2$) with *sec*-BuLi/TMEDA Followed by Addition of Methanol-d_4. According to the general procedure, 1.22 mmol of *sec*-BuLi/TMEDA was treated with 0.098 g (0.31 mmol) of ester for 1 h followed by excess methanol-d_1 to give a clear, colorless oil. The crude product was purified by MPLC on basic alumina with hexane as an eluent to give 0.070 g (72%) of a clear, light yellow oil. Mass spectral analysis of the product indicated 98% d_1 material: ^{1}H NMR ($CDCl_3$) δ 1.27 (d, J = 7 Hz, 18 H, $ArCH(CH_3)_2$), 2.30 (s, 6 H, $OCH(D)CH_2N(CH_3)_2$), 2.67 (t, J = 7 Hz, 2 H, $OCH(D)CH_2N(CH_3)_2$), 2.87 (m, 3 H, $ArCH(CH_3)_2$), 4.40 (t, J = 7 Hz, 1 H, $OCH(D)CH_2N(CH_3)_2$), 6.97 (s, 2 H, Ar H).

Reaction of 2 (R = $CH_2N(CH_3)_2$) with *sec*-BuLi/TMEDA Followed by Addition of 1-Iodobutane. According to the general procedure, 2.99 mmol of *sec*-BuLi/TMEDA was treated with 0.2388 g (0.75 mmol) of ester for 1 h, followed by the addition of 2 mL of 1-iodobutane to give a clear, brown oil. The crude product was purified by MPLC on basic alumina with 5:95 ether/hexane as an eluent to give 0.062 g (22%) of a clear, colorless oil: ^{1}H NMR ($CDCl_3$) δ 0.90 (m, 3 H, $OCH((CH_2)_3CH_3)CH_2N(CH_3)_2$), 1.28 (d, J = 7 Hz, 18 H, $ArCH(CH_3)_2$), 1.60 (m, 6 H, $OCH((CH_2)_3CH_3)CH_2N(CH_3)_2$), 2.23 (s, 6 H, $OCH((CH_2)_3CH_3)N(CH_3)_2$), 2.50 (m, 2 H, $OCH((CH_2)_3CH_3)CH_2N(CH_3)_2$), 3.03 (m, 3 H, $ArCH(CH_3)_2$), 5.30 (m, 1 H, $OCH((CH_2)_3CH_3)CH_2N(CH_3)_2$), 6.93 (s, 2 H, Ar H); IR (neat) 1725 cm^{-1} (C=O). Anal. ($C_{24}H_{41}NO_2$) C, H, N.

Treatment of 2 (R = $(CH_2)_{14}CH_3$) with *sec*-BuLi/TMEDA Followed by Addition of Methanol-d_4. According to the general procedure, 1.60 mmol of *sec*-BuLi/TMEDA was treated with 0.189 g (0.40 mmol) of ester followed by the addition of excess methanol-d_1 to give a clear, yellow oil. The oil was purified via preparative TLC on silica with 30:70 ether/hexane as an eluent to give 0.155 g (82%) of a white solid. Mass spectral analysis of the solid indicated 23% d_1 material: ^{1}H NMR ($CDCl_3$) δ 1.23 (m, 49 H, $ArCH(CH_3)_2$, $OCH(D)(CH_2)_{14}CH_3$), 2.83 (m, 3 H, $ArCH(CH_3)_2$), 4.26 (m, 1.8 H, $OCH(D)(CH_2)_{14}CH_3$), 6.93 (s, 2 H, Ar H).

Reaction of 2 (R = CH_2OCH_3) with *sec*-BuLi/TMEDA Followed by Addition of Methanol. To a solution of 2.18 mmol of 1:1 *sec*-BuLi/TMEDA in THF at −78 °C under Ar was added a solution of 1.67 g (0.55 mmol) of ester. The reaction mixture was stirred 1 h at −78 °C followed by the additon of excess methanol. The reaction mixture was warmed to ambient temperature, and ether was added. The reaction mixture was washed with saturated NH_4Cl solution and dried ($CaSO_4$), and the solvent was removed under reduced pressure to give a clear, colorless oil. The oil was purified by preparative TLC on silica with 30:70 ether/hexane as an eluent to give 0.124 g (82%) of the vinyl ester 7 as a clear, colorless oil: ^{1}H NMR ($CDCl_3$) δ 1.23 (d, J = 7 Hz, 18 H, $ArCH(CH_3)_2$), 2.87 (m, 3 H, $ArCH(CH_3)_2$), 4.63 (d, J = 7 Hz, 1 H, $OCHCH(H)$), 4.90 (d, J = 7 Hz, $OCHCH(H)$), 7.00 (s, 2 H, Ar H), 7.46 (m, 1 H, $OCHCH_2$); IR (neat) 1750 cm^{-1} (C=O). Anal. ($C_{18}H_{26}O_2$) C, H.

Reaction of 2 (R = CH_2OCH_3) with *sec*-BuLi/TMEDA Followed by Addition of Methyl Iodide. According to the immediately preceding procedure, 2.43 mmol of *sec*-BuLi/TMEDA was treated with 0.186 g (0.61 mmol) of ester followed by the addition of excess methyl iodide to give a clear, colorless oil. The oil was purified by preparative TLC on silica to give 0.128 g (73%) of 8 as a clear, colorless oil: ^{1}H NMR ($CDCl_3$) δ 1.26 (d, J = 7 Hz, 18 H, $ArCH(CH_3)_2$), 2.07 (s, 3 H, $OC(CH_3)CH_2$), 2.93 (m, 3 H, $ArCH(CH_3)_2$), 4.80 (s, 2 H, $OC(CH_3)CH_2$), 6.97 (s, 2 H, Ar H); IR (neat) 1745 cm^{-1} (C=O). Anal. ($C_{19}H_{28}O_2$) C, H.

Reaction of 2 (R = $CH=CH_2$) with *sec*-BuLi/TMEDA Followed by Addition of Water. According to the immediately preceding procedure, 3.29 mmol of *sec*-BuLi/TMEDA was treated with 0.237 g (0.83 mmol) of ester for 1 h followed by addition of excess water to give a yellow oil. The crude product mixture was purified by MPLC on silica with 1:99 ether/hexane as an eluent to give 0.125 g (53%) of a clear, colorless oil. ^{1}H NMR analysis of the product indicated 9 (20%) and 10 (80%): ^{1}H NMR ($CDCl_3$) δ 1.20 (m, 18.6 H, $ArCH(CH_3)_2$, $CO(CH_2)CH_3$), 1.80 (d, J = 8 Hz, 2.4 H, $C(OH)CHCH_3$), 2.70 (m, 3.4 H, $ArCH(CH_3)_2$, $CO(CH_2)CH_3$), 5.33 (q, J = 6 Hz, 0.8 H, $C(OH)CHCH_3$), 6.60 (s, 0.8 H, $C(OH)CHCH_3$), 7.00 (s, 2 H, Ar H); IR (neat) 1605 (C=C), 1640 (C=O), 1675 (C=O) cm^{-1}; mass spectrum, *m/e* (relative intensity) 290 (2), 289 (19), 288 (100), 273 (16), 259 (26), 245 (45), 231 (52). Anal. ($C_{19}H_{28}O_2$) C, H.

Reaction of 3 (R = CH_3) with *sec*-BuLi/TMEDA Followed by Addition of Methanol-d_4. To a solution of 1:1 *sec*-BuLi/TMEDA (0.97 mmol) in 3–5 mL of THF at −78 °C was added a solution of 0.0779 g (0.24 mmol) of ester in 2 mL of THF with stirring. The reaction mixture was stirred at −78 °C for 5 h followed by the addition of 1 mL of methanol-d_4 at −78 °C. The reaction mixture was warmed to room temperature. Ether was added, the organic phase was washed with saturated NH_4Cl so-

lution and dried ($CaSO_4$), and the solvent was removed under reduced pressure to give a white solid. The crude product was purified by preparative TLC on silica with 35:65 ether/hexane as an eluent to give 0.055 g (71%) of a white solid, mp 102–104 °C. Mass spectral analysis of the product indicated 91% d_1 incorporation: ^{1}H NMR ($CDCl_3$) δ 1.18 (d, J = 6 Hz, 12 H, $ArCH(CH_3)_2$), 1.36 (d, J = 8 Hz, 3 H, $OCH(D)CH_3$), 2.73 (s, 12 H, $ArN(CH_3)_2$), 3.23 (m, 2 H, $ArCH(CH_3)_2$), 4.25 (m, 1 H, $OCH(D)CH_3$), 7.00 (s, 1 H, Ar H).

Reaction of 3 (R = CH_3) with *sec*-BuLi/TMEDA Followed by Addition of Allyl Bromide. According to the immediately preceding procedure, 1.15 mmol of *sec*-BuLi/TMEDA was treated with 0.092 g (0.288 mmol) of ester, followed by addition of 1 mL of allyl bromide. The crude product was purified via MPLC on silica with 0.8:99.2 ether/hexane as an eluent to give 0.07 g (66%) of a white solid: mp 49.5–51 °C; ^{1}H NMR ($CDCl_3$) δ 1.20 (d, J = 7 Hz, 12 H, $ArCH(CH_3)_2$), 1.30 (m, 3 H, $OCH(CH_2CHCH_2)CH_3$), 2.36 (m, 2 H, $OCH(CH_2CHCH_2)CH_3$), 2.30 (s, 12 H, $ArCH(CH_3)_2$), 3.16 (m, 2 H, $ArCH(CH_3)$), 5.13 (m, 3 H, $OCH(CH_2CHCH_2)CH_3$), 5.80 (m, 1 H, $OCH(CH_2CHCH_2)CH_3$), 7.03 (s, 1 H, Ar H); IR 1735 cm^{-1} (C=O); mass spectrum, m/e (relative intensity) 362 (3), 361 (25), 360 (96), 292 (16), 291 (72), 275 (100), 259 (55), 248 (17), 247 (81). Anal. ($C_{22}H_{36}N_2O_2 \cdot 0.33H_2O$) C, H, N.

Reaction of 3 (R = CH_3) with *sec*-BuLi/TMEDA Followed by Addition of Chlorotrimethylsilane. According to the immediately preceding procedure, 1.16 mmol of *sec*-BuLi/TMEDA was treated with 0.093 g (0.29 mmol) of the ester followed by the addition of 1 mL of chlorotrimethylsilane to give a clear, colorless oil. The crude product was purified by preparative TLC on silica with 40:60 ether/hexane as an eluent to give 0.108 g of a white solid which was recrystallized from acetone to give 0.10 g (88%) of a white solid: mp 113.5–115 °C; ^{1}H NMR ($CDCl_3$) δ 0.10 (s, 9 H, $OCH(Si(CH_3)_3)CH_3$), 1.17 (d, J = 7 Hz, 12 H, $ArCH(CH_3)_2$), 1.33 (d, J = 7 Hz, 3 H, $OCH(Si(CH_3)_3)CH_3$), 2.70 (s, 12 H, $ArN(CH_3)_2$), 3.20 (m, 2 H, $ArCH(CH_3)_2$), 4.82 (q, J = 8 Hz, 1 H, $OCH(Si(CH_3)_3)CH_3$), 7.00 (s, 1 H, Ar H); IR (mull) 1735 cm^{-1} (C=O); mass spectrum, m/e (relative intensity) 392 (19), 276 (23), 275 (100), 259 (7), 247 (12). Anal. ($C_{22}H_{40}N_2O_2Si$) C, H.

Reaction of 3 (R = CH_3) with *sec*-BuLi/TMEDA Followed by Addition of Tetra-*n*-butyltin Chloride. According to the above procedure, 1.42 mmol of *sec*-BuLi/TMEDA was treated with 0.114 g (0.355 mmol) of ester, followed by the addition of 1 mL of tetra-*n*-butyltin chloride in 1 mL of THF. The crude product was purified by MPLC on silica with 0.75:99.25 ether/hexane as an eluent to give 0.109 g (50%) of a clear, colorless oil: ^{1}H NMR ($CDCl_3$) δ 0.73–1.93 (m, 42 H, $ArCH(CH_3)$, $OCH(Sn((CH_2)_3CH_3)_3)CH_3$), 2.70 (s, 12 H, $ArN(CH_3)_2$), 3.13 (m, 2 H, $ArCH(CH_3)_2$), 4.97 (q, J = 7 Hz, 1 H, $OCH(Sn((CH_2)_3CH_3)_3)CH_3$), 7.00 (s, 1 H, Ar H); IR (mull) 1735 cm^{-1} (C=O); mass spectrum, m/e (relative intensity) 610 (1), 609 (2), 558 (3), 557 (12), 551 (52), 319 (34), 275 (100). Anal. ($C_{31}H_{58}N_2O_2Sn$) C, H, N.

Reaction of 3 (R = CH_3) with *sec*-BuLi/TMEDA Followed by Addition of Acetone-d_6. According to the above procedure, 1.36 mmol *sec*-BuLi/TMEDA was treated with 0.109 g (0.34 mmol) of ester followed by addition of 1 mL of acetone-d_6 to give a white solid. The crude product was purified by preparative TLC on silica with 40:60 ether/hexane as an eluent to give 0.093 g (70%) of a white solid: mp 123–125 °C; ^{1}H NMR ($CDCl_3$) δ 1.22 (m, 15 H, $ArCH(CH_3)_2$, $OCH(C(OH)(CD_3)CH_3)$), 2.73 (s, 12 H, $ArN(CH_3)_2$), 3.21 (m, 2 H, $ArCH(CH_3)_2$), 5.20 (q, J = 7 Hz, 1 H, $OCH(C(OH)(CD_3)_2)CH_3$), 7.03 (s, 1 H, Ar H); IR (mull) 1735 cm^{-1} (C=O); mass spectrum, m/e (relative intensity) 385 (16), 384 (64), 275 (100), 259 (44), 247 (52). Anal. ($C_{22}H_{32}D_6N_2O_3$) C, H, N.

Reaction of 3 (R = n-C_4H_9) with *sec*-BuLi/TMEDA Followed by Addition of Methanol-d_1. According to the above procedure, 0.80 mmol of *sec*-BuLi/TMEDA was treated with 0.061 g (0.20 mmol) of ester followed by the addition of methanol-d_1 to give a white solid. The crude product was purified by preparative TLC on silica with 35:65 ether/hexane as an eluent to give 0.055 g (90%) of a white solid: mp 134–136 °C. Mass spectral analysis of the product indicated 99% d_1 material: ^{1}H NMR ($CDCl_3$) δ 1.17 (d, J = 7 Hz, 12 H, $ArCH(CH_3)_2$), 2.73 (s, 12 H, $ArN(CH_3)_2$), 3.23 (m, 2 H, $ArCH(CH_3)_2$), 3.82 (m, 2 H, OCH_2D), 7.00 (s, 1 H, Ar H).

Reaction of 3 (R = $(CH_2)_3CH_3$) with *sec*-BuLi/TMEDA Followed by Addition of Methanol-d_1. According to the above procedure, 0.92 mmol of *sec*-BuLi/TMEDA was treated with 0.084 g (0.23 mmol) of ester followed by the addition of methanol-d_1 to give a white solid. The crude product was purified by preparative TLC on silica with 35:65 ether/hexane as an eluent to give 0.073 g (87%) of a white solid, mp 68–69.5 °C. Mass spectral analysis of the product indicated 99% d_1 material: ^{1}H NMR ($CDCl_3$) δ 0.90 (m, 3 H, $OCH(D)(CH_2)_3CH_3$), 1.10–1.93 (m, 18 H, $ArCH(CH_3)_2OCH(D)(CH_2)_3CH_3$), 2.70 (s, 12 H, $ArN(CH_3)_2$), 3.17 (m, 2 H, $ArCH(CH_3)$), 4.23 (m, 1 H, $OCH(D)(CH_2)_3CH_3$), 7.00 (s, 1 H, Ar H).

2′-Hexyl 3,5-Dinitobenzoate from Reaction of 3 (R = CH_3) with *sec*-BuLi/TMEDA Followed by Additon of 1-Iodobutane and Treatment with HCl/THF. To a solution of 1:1 *sec*-BuLi/TMEDA (5.75 mmol) in THF stirred at −78 °C under Ar was added a solution of 0.461 g (1.44 mmol) of ester in THF. After the reaction mixture stirred 5 h at −78 °C, 5 mL of 1-iodobutane was added. The reaction mixture was warmed to ambient temperature, and ether was added. The reaction mixture was washed with saturated NH_4Cl solution and dried, and the solvent was removed under reduced pressure to give a brown oil and solid. A solution of the oil and solid, 30 mL of 10% HCl, and 10 mL of THF was heated at reflux for 23 h and cooled to ambient temperature. The pH of the reaction mixture was adjusted to 14. Insoluble solids were removed via filtration. The reaction mixture was washed with ether and dried ($CaSO_4$), and the solvent was removed under reduced pressure to give a brown oil. A solution of the brown oil, 1.0 g of 3.5-dinitrobenzoylchloride, and 20 mL of ether was heated at reflux for 4 h. the reaction mixture was cooled to ambient temperature, and ether was added. The reaction mixture was washed with 10% $NaHCO_3$ followed by H_2O and dried ($CaSO_4$). The solvent of the mixture was removed under reduced pressure to give an oil. The oil was purified by MPLC on silica with 5:95 ether/hexane as an eluent to give 0.286 g (67%) of the 3,5-dinitrobenzoate of 2-hexanol as a white solid, mp 36–37.5 °C (lit.[30] mp 36–37.5 °C).

2′-Nonyl 3,5-Dinitrobenzoate from Reaction of 3 (R = CH_3) with *sec*-BuLi/TMEDA Followed by Addition of 1-Iodoheptane and Treatment with HCl/THF. By use of the above procedure, 3.42 mmol of *sec*-BuLi/TMEDA was treated with 0.274 g (0.86 mmol) of ester followed by the addition of 4 mL of 1-iodoheptane. An extractive workup gave an oil from which excess 1-iodoheptane was removed by distillation with a Kugelrohr apparatus. The hydrolysis of the oil was performed with 10% HCl/THF for 24 h. The 3,5-dinitrobenzoate of the 2-nonanol was prepared and purified by MPLC on silica to give 0.110 g (38%) of the 3,5-dinitrobenzoate as a white solid, mp 43–45 °C (lit.[31] mp 43 °C).

Treatment of 11 with H_2SO_4. A solution of 80 mL of concentrated sulfuric acid at 0 °C was added to 0.823 g (2.19 mmol) of **11**. The reaction mixture was stirred at 0 °C for 0.5 h until a homogeneous solution was obtained. Ice was added to the reaction mixture and insoluble material removed via filtration. The aqueous filtrate was washed with ether, the organic phase was dried ($CaSO_4$), and the solvent was removed under reduced pressure to give a clear, yellow oil. The oil was purified by MPLC on silica with 1:99 ether/hexane as an eluent to give a clear, colorless oil which was treated with 2,4-dinitrophenylhydrazine to give 0.27 g of the 2,4-dinitrophenylhydrazone of cyclohexyl methyl ketone as a yellow solid, mp 135–137 °C (lit.[31] mp 140 °C). IR and ^{1}H NMR spectral properties of the ketone and ^{1}H NMR properties of the 2,4-dinitrophenylhydrazone derivative were consistent with the assigned structure.

Reaction of 2 (R = $CH_2CH_2CH_3$) with *sec*-BuLi/TMEDA Followed by Addition of Cyclohexane and H_2SO_4. By use of the previous procedure, 19.27 mmol of *sec*-BuLi/TMEDA was treated with 1.397 g (4.82 mmol) of **2** (R = CH_2CH_3) followed by addition of cyclohexanone to give a clear, yellow oil. ^{1}H NMR analysis of the crude product showed 47% α-substituted ester and starting ester. Excess cyclohexanone was removed from the reaction mixture by distillation, and the concentrated reaction mixture was subjected to MPLC on silica with 1:99 ether/hexane

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as an eluent. The resultant material was added to 80 mL of concentrated H_2SO_4 stirred at 0 °C. The reaction mixture was stirred 1.75 h at 0 °C until a homogenous solution was obtained. Ice was added, and the aqueous phase was extracted with ether. The organic phase was dried and the solvent removed under reduced pressure to give an oil which was subjected to MPLC on silica with 1:99 ether/hexane as an eluent to afford a clear, colorless oil. The oil was treated with 2,4-dinitrophenylhydrazone solution to give 2.71 (18%) of the 2,4-dinitrophenylhydrazone of cyclohexyl ethyl ketone as an orange solid, mp 147–148 °C (lit.[32] mp 149–151 °C).

Acknowledgment. We are grateful to the National Institutes of Health, Institute of General Medicine, for support of this work and to Dr. M. Baillargeon for advice and assistance.

Registry No. **2** (R = Me), 63846-76-4; **2** (R = Et), 77256-39-4; **2** (R = *n*-heptyl), 77256-40-7; **2** (R = Ph), 77256-41-8; **2** (R = CH_2OMe), 77256-42-9; **2** (R = CH_2NMe_2), 77256-43-0; **2** (R = *n*-pentadecyl), 77256-44-1; **2** (R = $CH=CH_2$), 77256-45-2; **3** (R = Me), 77256-46-3; **3** (R = H), 77256-47-4; **3** (R = *n*-butyl), 77256-48-5; **6** (Ar = 2,4,6-triisopropylphenyl; R = Me; E = D), 77256-49-6; **6** (Ar = 2,4,6-triisopropylphenyl; R = Me; E = $CH_2CH=CH_2$), 68027-60-1; **6** [Ar = 2,4,6-triisopropylphenyl; R = Me; E = $(CH_2)_3CH_3$], 77256-50-9; **6** [Ar = 2,4,6-triisopropylphenyl; R = Me; E = Sn $[(CH_2)_3CH_3]_3$], 68058-27-5; **6** [Ar = 2,4,6-triisopropylphenyl; R = Me; E = $Si(CH_3)_3$], 68027-61-2; **6** [Ar = 2,4,6-triisopropylphenyl; R = CH_3; E = $HOC(CH_3)_2$], 68027-59-8; **6** [Ar = 2,4,6-triisopropylphenyl; R = CH_3; E = $HOC(CD_3)_2$], 68027-62-3; **6** [Ar = 2,4,6-triisopropylphenyl; R = Me; E = $HOC(CH_2)_5$], 77256-51-0; **6** [Ar = 2,4,6-triisopropylphenyl; R = Me; E = $HOCHCH_3$], 77256-52-1; **6** [Ar = 2,4,6-triisopropylphenyl; R = Me; E = $CH_2N(CH_3)_2$], 77256-53-2; **6** [Ar = 2,4,6-triisopropylphenyl; R = Me; E = $HOCCH=CH(CH_2)_3$], 77256-54-3; **6** [Ar = 2,4,6-triisopropylphenyl; R = Et; E = D], 77256-55-4; **6** [Ar = 2,4,6-triisopropylphenyl; R = Et; E = $HOC(CH_3)_2$], 77256-56-5; **6** (Ar = 2,4,6-triisopropylphenyl; R = Et; E = $CH_2CH=CH_2$), 77256-57-6; **6** [Ar = 2,4,6-triisopropylphenyl; R = $(CH_2)_6CH_3$; E = D], 77256-58-7; **6** [Ar = 2,4,6-triisopropylphenyl; R = $(CH_2)_6CH_3$; E = $CH_2CH=CH_2$], 77256-59-8; **6** [Ar = 2,4,6-triisopropylphenyl; R = $(CH_2)_6CH_3$; E = $Si(CH_3)_3$], 77256-60-1; **6** [Ar = 2,4,6-triisopropylphenyl; R = $(CH_2)_6CH_3$; E = $HOC(CH_3)_2$], 77256-61-2; **6** (Ar = 2,4,6-triisopropylphenyl; R = Ph; E = CH_3), 77256-62-3; **6** [Ar = 2,4,6-triisopropylphenyl; R = $CH_2N(CH_3)_2$; E = D], 77256-63-4; **6** [Ar = 2,4,6-triisopropylphenyl; R = $CH_2N(CH_3)_2$; E = $(CH_2)_3CH_3$], 77256-64-5; **6** [Ar = 2,4,6-triisopropylphenyl; R = $(CH_2)_{14}CH_3$; E = D], 77256-65-6; **6** [Ar = 2,6-bis(dimethylamino)-3,5-diisopropylphenyl; R = Me; E = D], 77256-66-7; **6** [Ar = 2,6-bis(dimethylamino)-3,5-diisopropylphenyl; R = CH_3; E = $CH_2CH=CH_2$], 77256-67-8; **6** [Ar = 2,6-bis(dimethylamino)-3,5-diisopropylphenyl; R = CH_3; E = $Si(CH_3)_3$], 77256-68-9; **6** [Ar = 2,6-bis(dimethylamino)-3,5-diisopropylphenyl; R = CH_3; E = Sn $[(CH_2)_3CH_3]_3$], 77256-69-0; **6** [Ar = 2,6-bis(dimethylamino)-3,5-diisopropylphenyl; R = CH_3; E = $HOC(CD_3)_2$], 77256-70-3; **6** [Ar = 2,6-bis(dimethylamino)-3,5-diisopropylphenyl; R = C_4H_9; E = D], 77256-71-4; **7** (E = H), 77256-72-5; **8** (E = CH_3), 77256-73-6; **9**, 77256-74-7; **10**, 77256-75-8; **11** [Ar = 2,4,6-(*i*-Pr)$_3$Ph; R = CH_3], 77256-51-0; **12** [Ar = 2,4,6-(*i*-Pr)$_3$Ph; R = Et], 77256-76-9; 2,4,6-triisopropylbenzoic acid, 49623-71-4; 2,4,6-triisopropylbromobenzene, 21524-34-5; isopropyl 2,4,6-triisopropylbenzoate, 77256-77-0; 1,3-diisopropyl-4,6-dinitrobenzene, 77256-78-1; 4,6-diamino-1,3-diisopropylbenzene, 3102-71-4; 2,6-diamino-3,5-diisopropylbromobenzene, 77256-79-2; 2,6-bis(dimethylamino)-3,5-diisopropylbromobenzene, 77256-80-5; 2,6-bis(dimethylamino)-3,5-diisopropylbenzoic acid, 77256-81-6; isopropyl 2,6-bis(dimethylamino)-3,5-diisopropylbenzoate, 77256-82-7; 2-(2-phenylpropyl) 2,4,6-triisopropylbenzoate, 77256-83-8; 2-heptanol, 543-49-7; 2′-hexyl 3,5-dinitrobenzoate, 10574-13-7; 2′-nonyl 3,5-dinitrobenzoate, 77256-84-9; 2-methyl-2,3-butanediol, 5396-58-7; cyclohexyl methyl ketone 2,4-dinitrophenylohydrazone, 1160-74-3; cyclohexyl ethyl ketone 2,4-dinitrophenylhydrazone, 1163-56-0; *m*-diisopropylbenzene, 99-62-7.

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Preparation, Characterization, and Flash Vacuum Pyrolysis of Dibenz[*c*,*e*][1,2]oxathiin 6-Oxide (Biphenylene Sultine)

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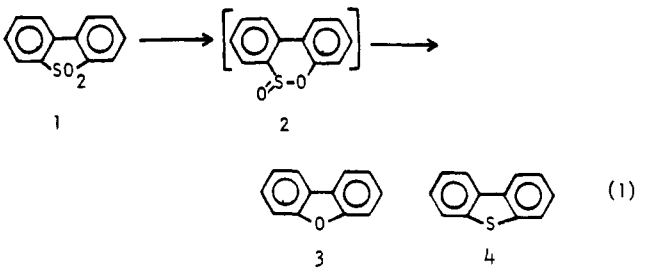
Received March 11, 1981

Dibenz[*c*,*e*][1,2]oxathiin 6-oxide (**2**), previously proposed as an intermediate in the pyrolysis of dibenzothiophene 5,5-dioxide (**1**), has been prepared by the treatment of **1** with KOH in the presence of crown ether followed by an acid workup. The likely intermediacy of the dipotassium salt of 2-(2-hydroxyphenyl)benzenesulfinic acid is demonstrated. Flash pyrolysis of **2** gives dibenzofuran and dibenzothiophene in essentially the same ratio as when they are formed in the pyrolysis of **1**, suggesting that both products arise from the intermediacy of **2**.

Pyrolysis of dibenzothiophene 5,5-dioxide (**1**) at 690 °C over Vycor chips with contact times of 15 s is reported to afford a 95% yield of a 6:1 mixture of dibenzofuran (**3**) and dibenzothiophene (**4**)[1] (eq 1). Fields and Meyerson proposed that **1** rearranges to sultine **2** which extrudes SO to give **3**.[1] A mechanism to account for the formation of **4** was not suggested. The proposal of the intermediacy of sultine **2** has not been verified because, until now, it has not been prepared. Fully unsaturated 1,2-oxathiins are known only with sulfur in the +6 oxidation state (sul-



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†Operated for the U.S. Department of Energy by Iowa State University under Contract No. W-7405-Eng-82. This research was supported by the Assistant Secretary for Fossil Energy, Office of Coal Mining, WPAS-AA-75-05-05.

0022-3263/81/1946-2373$01.25/0