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REACTIONS OF ORTHOFORMATES WITH ALKYLLITHIUM REAGENTS. A NOVEL SYNTHESIS OF INTERNAL OLEFINS.

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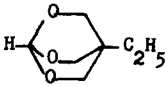
Orthoesters are converted to acetals when treated with Grignard reagents (1.2). Surprisingly very little work has been reported on reactions with lithium reagents. We have found that alkyllithium reagents react with several orthoesters to give internal olefins. For example, addition of I to butyllithium (1:5 molar ratio) under nitrogen in ether-cyclohexane was exothermic. When the

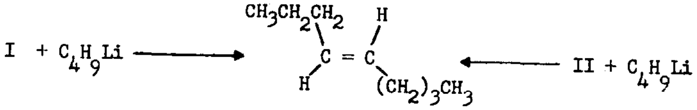
$H\text{-}C(OCH_3)_3$

I



II

the mixture was slowly heated to 60° (1 hr.), a precipitate formed. The mixture was stirred at reflux for an additional 0.5 hr. and allowed to cool to room temperature. Decomposition was effected with ice water, and distillation of the organic phase gave trans-4-nonene. Infrared analysis showed a strong band at 969cm.$^{-1}$ for the trans double bond (3). Oxidative ozonolysis of the olefin and methylation of the acidic products with diazomethane, gave methyl n-butyrate and methyl n-valerate. 4-Ethyl-2,6,7-trioxabicyclo[2.2.2]octane (4) and n-butyllithium under similar conditions gave a vastly improved yield of trans-4-nonene as shown in TABLE I. In addition to starting material, which could be isolated from both experiments, several minor components were detected by gas chromatography analyses.



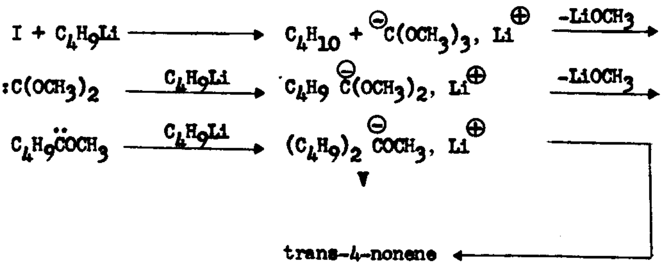
With n-hexyllithium the striking increase in yield of *trans*-6-tridecene was again observed in going from I to II as a coreactant. Identification of the olefin was completed by infrared and n.m.r. analyses and by comparison of physical properties with those previously reported (5). n-Heptyllithium and I gave *trans*-7-pentadecene which was isolated by distillation and preparative gas chromatography and authenticated by infrared and n.m.r. spectroscopy (6).

Studies on the base-catalyzed (potassium t-butoxide) hydrogen exchange of triethyl orthoformate with tritium (7a) and 1-deuterio-4-methyl-2,6,7-trioxabicyclo[2.2.2]octane in t-butanol (7b) demonstrated that abstraction of hydrogen or deuterium was extremely slow. The explanation included the suggestion that carbanion III is probably much less stable than the sulfur analog IV which is

$$\ominus C(OR)_3 \qquad\qquad \ominus C(SR)_3$$

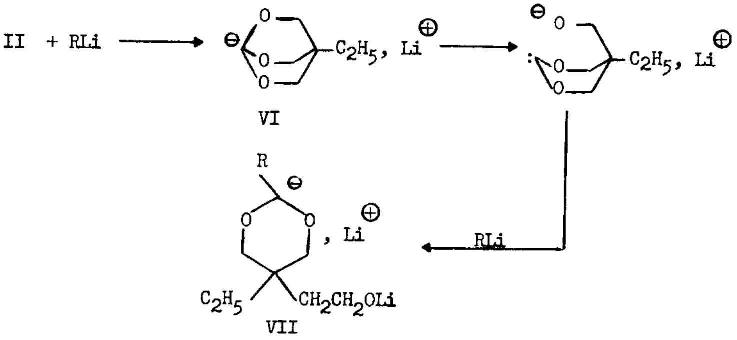
III IV

apparently formed with ease from the corresponding alkyl orthothioformate. In the present study, butane was rapidly evolved upon addition of II to butyllithium which implies rapid abstraction of hydrogen. A carbene mechanism is proposed to explain the formation of olefins from the anions of I and II. Inherent features of carbenes of the type $C(XR)_2[X=O,S]$ have prevented capture by simple olefins (8,9) as we have also observed in this investigation. If the mechanism is viewed as follows, the carbenes generated might well be consumed by the reactive butyl anion present in excess (10). Creation of the double bond in conversion of V to



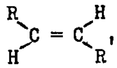
$$\begin{array}{lll}
\text{I} + C_4H_9Li \longrightarrow & C_4H_{10} + {}^{\ominus}C(OCH_3)_3,\ Li^{\oplus} & \xrightarrow{-LiOCH_3} \\
:C(OCH_3)_2 \xrightarrow{C_4H_9Li} & C_4H_9\overset{\ominus}{C}(OCH_3)_2,\ Li^{\oplus} & \xrightarrow{-LiOCH_3} \\
C_4H_9\ddot{C}OCH_3 \xrightarrow{C_4H_9Li} & (C_4H_9)_2\overset{\ominus}{C}OCH_3,\ Li^{\oplus} & \longrightarrow \text{trans-4-nonene} \\
 & \text{V} &
\end{array}$$

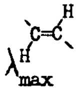
the alkene may be explained by migration of a hydride ion (11). Direct displacement of a methoxy group from tris-(methyloxy) methyllithium is conceivable but models imply a steric factor may be prominent (12). This alternative mechanism involving nucleophilic attack of butyllithium on the ortho ester II or the anion VI seems highly improbable because of the molecular geometry of both species. Indeed, one interpretation of the improved yield of alkene with II would include relief of strain in the ring-opening step to give the carbene. Solvation factors are probably important, and whether a classic nucleophilic displacement reaction of



butyllithium on VI or VII occurs or a carbene mechanism is operative cannot be definitively stated at this time.

TABLE I

Trans-Olefins 

Moles R'Li / Moles Orthoformate	R	R'	Yield (%)	 λ_{max} ,cm.$^{-1}$
5 (I) 4 (II)	C_3H_7	C_4H_9	43 76	969
3.5 (I) 3.7 (II)	C_5H_{11}	C_6H_{13}	37 74	969
3.5 (I)	C_6H_{13}	C_7H_{15}	33	965

ACKNOWLEDGMENT

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REFERENCES

(1) The early work has been summarized: see H. W. Post, *The Chemistry of Aliphatic Orthoesters*, Reinhold Publ. Corp., New York, 1943, Chpt. 6.

(2) R. C. Fuson, *Reactions of Organic Compounds*, John Wiley and Sons, Inc., New York, 1962, p. 451.

(3) Although 4-nonene has been reported recently, no assignment of stereochemistry was made, see V. Franzen and L. Fikentscher, *Ber.*, *95*, 1958 (1962). Our sample was of purity greater than 99% by gas chromatography, b.p. 143-4° 731 mm., n_D^{27} 1.4168 (lit. 145-6°, n_D^{18} 1.4224).

(4) Available from Kay-Fries Chemicals, Inc., New York 17, New York.

(5) A. A. Petrov, S. R. Sergienko, A. L. Tsedilina and Y. P. Egorov, *Khim. i Tekhnol Topliva*, No. I, 26 (1956); *Chem. Abstr.* *50*, 16655 (1956).

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(7) a. L. H. Slaugh and E. Bergman, *J. Org. Chem.* *26*, 3158 (1961).

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(8) U. Schollkopf and E. Wiskott, *Angew. Chem. Internat. Ed.*, *2*, 485 (1963). Bis-(methylthio)-methylene was trapped with an activated olefin, 1-morpholine-1-phenylethylene.

(9) R. J. Crawford and R. Raap, *Proc. Chem. Soc.*, 370 (1963).

(10) It has been pointed out that formation of tetrakis-(methylthio)-ethylene could result from attack of bis-(methylthio)-methylene on tris-(methythio)-methylanion rather than via coupling of 2 molecules of the methylenes; see, J. Hine, R. P. Bayer, and G. G. Hammer, *J. Am. Chem. Soc.*, *84*, 1752 (1962).

(11) A similar situation has been observed when butyllithium was treated with chlorocarbene to give 1-pentene; see G. L. Closs and L. E. Closs *J. Am. Chem. Soc.*, *81*, 4996 (1959). More recently, several internal olefins were suggested to arise by a carbene mechanism when trifluorobromomethane or difluorobromomethane was treated with primary alkyllithium or Grignard reagents, see reference 3.

(12) Nucleophilic attack of cyclohexene on trichloromethyllithium, was tentatively postulated to rationalize the high yield of 7,7-dichloronorcarane rather than a classic addition of dichlorocarbene to the olefin; see, W. T. Miller, Jr. and D. M. Whalen, *J. Am. Chem. Soc.*, *86*, 2089 (1964).