

A Convenient Synthesis of Trans Olefins from Alkynes via Hydroboration-Cyanohalogenation¹

Sir:

Recently we disclosed a convenient method for the stereospecific synthesis of cis disubstituted or trisubstituted olefins from mono- or disubstituted alkynes, respectively, via their hydroboration to dialkylvinylboranes followed by the addition of sodium hydroxide and iodine.² In exploring possible routes for the stereospecific preparation of the corresponding trans olefins from the same dialkylvinylboranes, we have now found that this may be readily accomplished through their treatment with cyanogen bromide or cyanogen iodide in methylene chloride solution.³

The formation of cis olefins from dialkylvinylboranes via the iodination reaction has been rationalized in terms of (a) electrophilic addition of iodine to form a cyclic iodonium ion species, (b) alkyl group migration from boron to the adjacent carbon with inversion at the migration terminus, and (c) trans elimination of boron and iodide.² From consideration of the various stereochemical features of this proposed mechanism,⁴ it was anticipated that if the tendency of the boron to interact with the β halogen could be enhanced, for example, by introduction of a strongly electron-withdrawing group on boron, this would lead via a cis elimination to the formation of trans olefins. It was thought that one possible way to accomplish this would be by addition of cyanogen bromide or cyanogen iodide, rather than iodine, to the dialkylvinylborane. Both cyanogen halides possess the electrophilic halide and the electron-withdrawing cyano group necessary for the desired reaction to take place (Scheme I). Thus, dicyclohexyl-*trans*-1-hexenylborane in tetrahydrofuran solvent was treated with 1.33 equiv of cyanogen halide at 0–5° for 4 hr. The reaction mixtures were then diluted with 3 *N* sodium hydroxide, and the olefin products formed were extracted into pentane for analysis. The experimental results obtained are summarized in Table I.

The cis-trans olefin distributions observed clearly demonstrate the marked effect produced by the cyano group on the mode of elimination. Thus, addition of iodine to the dialkylvinylborane in tetrahydrofuran produces mainly the cis olefin, whereas cyanogen iodide under similar experimental conditions affords a nearly equal mixture of the cis and trans olefins. Furthermore, the use of cyanogen bromide leads to predominant cis elimination to give the trans olefin in greater than 90% isomeric purity,⁵ probably due to the bromide's more efficient interaction with the boron, thus increasing the importance of the cis-elimination process.⁶

(1) This research was supported by the National Science Foundation through Grant No. GP-26369.

(2) G. Zweifel, H. Arzoumanian, and C. C. Whitney, *J. Amer. Chem. Soc.*, **89**, 3652 (1967).

(3) Recently we have shown that α -halovinylboranes derived from 1-halo-1-alkynes and dialkylboranes, after successive treatment with sodium methoxide and acetic acid, also afford trans-disubstituted olefins. However, this procedure does not permit the preparation of trisubstituted olefins: G. Zweifel, R. P. Fisher, J. T. Snow, and C. C. Whitney, *J. Amer. Chem. Soc.*, **93**, 6909 (1971).

(4) It should be noted that the mechanism suggested has been used only as a working hypothesis and hence should not be regarded as firmly established.

(5) Considerable polymerization of the tetrahydrofuran was observed.

Scheme I

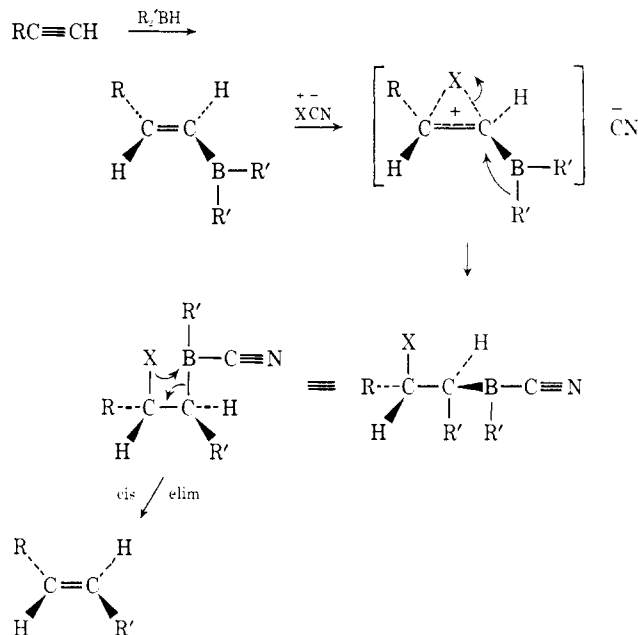


Table I. Effects of Changing the Nature of the Added Halide and the Solvent on the Distribution of *cis*- and *trans*-1-Cyclohexyl-1-hexenes Obtained from Dicyclohexyl-*trans*-1-hexenylborane

Halide	Solvent	Olefin		Total olefin Yield, % ^a
		Cis	Trans	
BrCN	THF	6	94	74
ICN	THF	46	54	85
I₂	THF	93	7	85
BrCN	CH₂Cl₂	4	96	80
ICN	CH₂Cl₂	6	94	74
I₂	CH₂Cl₂	23	77	13 ^b

^a The isomer distributions and the yields of olefins were determined by glpc. ^b Incomplete reaction because the iodine is very insoluble in methylene chloride.

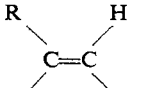
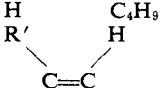

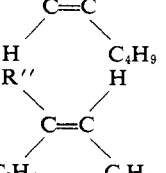
In an attempt to further assist the cis-elimination process, the reactions of cyanogen bromide and iodide with the dialkylvinylborane were also carried out in the less polar methylene chloride solvent. The results, which are also shown in Table I, indicate that under these conditions even cyanogen iodide produces the trans olefin in high isomeric purity.

Based on the above results, the following general procedure for the conversion of alkynes into trans olefins on a synthetic scale was adopted. The dialkylborane was prepared by hydroboration of the appropriate olefin (55 mmol) with BH₃ (27.5 mmol) in THF. To the solution was added the alkyne (25 mmol) in 10 ml of THF, while maintaining the temperature of the reaction mixture between 0 and 5°. The reaction mixture was allowed to warm slowly to room temperature and then maintained at this temperature for 30 min. After removal of the THF under reduced pressure at 0°, methylene chloride (10 ml) and cyanogen

(6) It is of interest to note, in connection with this work, that when *trans*-1-hexenyldicyclohexylborane in THF was treated with a solution of ICN in ether (1 equiv) at 25° for 4 hr followed by oxidation of the intermediate organoborane with alkaline hydrogen peroxide, glpc analysis indicated the formation of an 84% yield of 1-cyclohexyl-2-cyanoheptan-1-ol. We are continuing to explore the full scope of this remarkable reaction which represents a method for introducing three different substituents onto the triple bond of an alkyne.

bromide (33 mmol) in 40 ml of methylene chloride were added at 0°. The reaction mixture was stirred for 2 hr at 0°⁷ and then diluted with 15 ml of 6 *N* sodium hydroxide. The olefin formed was extracted into pentane and purified by distillation through a short Vigreux column. The results obtained from several reactions carried out following this general procedure are given in Table II.

Table II. Yields of Products Obtained from Reactions of Cyanogen Bromide with Various Dialkylvinylboranes in CH₂Cl₂

Hydroborating agent ^a	Alkyne	Olefin products (isomeric purity) ^{a,b}	Yield of trans olefin, %
R ₂ BH	1-Hexyne	 (96)	69
R ₂ 'BH	1-Hexyne	 (93)	68
R ₂ ''BH	1-Hexyne	 (98)	75 ^c
R ₂ ''BH	3-Hexyne	 (93)	63 ^d

^a R = cyclohexyl, R' = 2-methylcyclohexyl, R'' = 3-pinanyl.

^b The spectral data for all compounds reported are consistent with the structures proposed. ^c Yield by glpc. Others are isolated yields. ^d The structural assignment is based on the stereochemical result observed in the analogous reaction using 1-hexyne.

It should be noted in connection with the results shown in Table II that in the case using bis(*trans*-2-methylcyclohexyl)borane as the hydroborating agent in formation of the trans olefin product the *trans*-2-methylcyclohexyl group migrates from boron to carbon with retention of configuration. This behavior is similar to that observed in previous work with iodination of the dialkylvinylboranes.³ Thus, this novel reaction for the conversion of alkynes into di- and trisubstituted olefins of predictable stereochemistry represents a valuable addition to synthetic methodology.

(7) When bis(*trans*-2-methylcyclohexyl)borane was used as the hydroborating agent, the reaction mixture was stirred at 25° for 2 hr.

(8) National Defense Education Act Fellow (Title IV) at the University of California, Davis.

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The 4,5-Diphenyl-4-oxazolin-2-one Ring System as an Amine Protecting Group¹

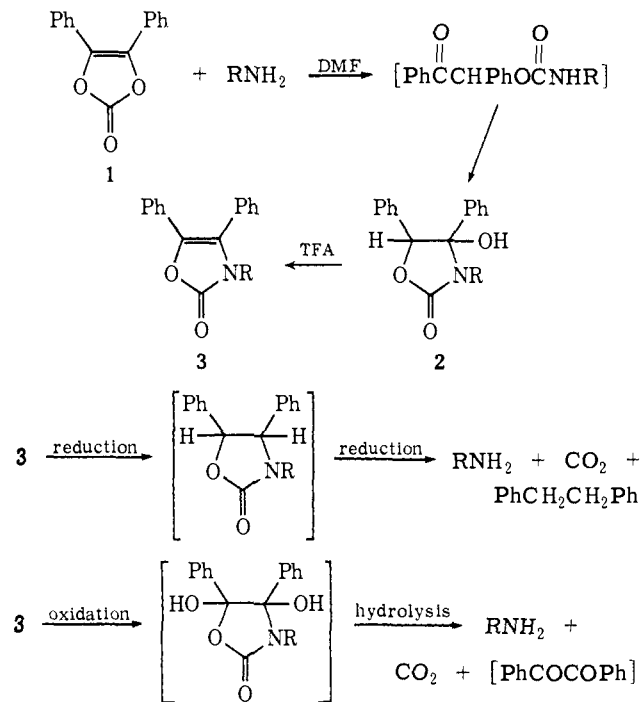
Sir:

Of the great variety of methods currently available for amino group protection, only a few methods re-

(1) Presented in part at the Third American Peptide Symposium, Boston, Mass., June 1972.

place both hydrogens of a primary amine function. Although such protection would eliminate or minimize the possibility of a variety of unwanted side reactions, protective groups of this type, which include the phthalimido,² arylidene,³⁻⁵ and other groups,^{6,7} have generally been of limited utility because of their solvolytic instability, even under mild conditions. We wish to report a novel method of amino group protection by the incorporation of a primary amine nitrogen into the extremely stable and unreactive 4,5-diphenyl-4-oxazolin-2-one ring system.⁸ Although the fluorescent and highly crystalline 4,5-diphenyl-4-oxazolin-2-one (Ox) protected derivatives, **3**, are unreactive under the great majority of conditions usually used to remove protective groups, the Ox group may be removed by low-pressure hydrogenolysis, sodium in liquid ammonia reduction, or relatively mild oxidative conditions (Chart I).

Chart I



The Ox derivatives are most conveniently prepared using the cyclic carbonate of benzoin **1**. This reagent may be prepared by treatment of a cooled (5°) stirred mixture of benzoin (1.0 equiv) and phosgene (1.1 equiv) in benzene with distilled *N,N*-dimethylaniline (1.0 equiv). After stirring overnight at room temperature, the mixture is filtered from *N,N*-dimethylaniline hydrochloride, and the filtrate refluxed for 3 hr to cyclize the initially formed unstable chloroformate. Washing with 1 *N* hydrochloric acid and water, drying over sodium sulfate, and removing the solvent, followed by recrystallization from 95% ethanol, afford the carbonate **1** [mp 75–76°; ir (CCl₄) 1870, 1840 (sh), 1820

(2) J. C. Sheehan and V. S. Frank, *J. Amer. Chem. Soc.*, **71**, 1856 (1949).

(3) B. Bezas and L. Zervas, *ibid.*, **83**, 719 (1961).

(4) J. C. Sheehan and V. J. Grenda, *ibid.*, **84**, 2417 (1962).

(5) E. Gazis, B. Bezas, G. C. Stelekatos, and L. Zervas, *Peptides, Proc. Eur. Symp.*, **5th**, 1962, 17 (1963).

(6) J. C. Sheehan and E. J. Corey, *J. Amer. Chem. Soc.*, **74**, 4555 (1952).

(7) L. A. Carpino, *J. Org. Chem.*, **29**, 2820 (1964).

(8) Reviewed in R. Filler, *Advan. Heterocycl. Chem.*, **4**, 103 (1965).