Table I. Electrophoresis of Thyrocalcitonin (Cellulose Acetate, 15 min at 30 v/cm)

Buffer	pH	Mobility, mm, of: Thyrocalcitonin	Reference dye: Amaranth red	Reference dye: Brilliant blue
0.2 *M* formic–0.2 *M* acetic acids	2	17	42	26
0.05 *M* sodium formate	3	18	41	23
0.02 *M* sodium phosphate	5	13	40	24
0.02 *M* sodium phosphate	7	7	45	30
0.01 *M* sodium borate	9	6	46	28

followed by acid hydrolysis and thin layer chromatography[6] gave O-dansyltyrosine and no other derivatives. Likewise, treatment with leucine aminopeptidase, under conditions which rapidly degraded a model peptide, did not hydrolyze thyrocalcitonin. Thus the new peptide hormone does not appear to contain a free terminal amino group, and five of the six potential carboxyl groups are present as amides.

From the above data we conclude that a pure peptide having hypocalcemic activity has been obtained. Other peptides having similar biological effects may be present in the thyroid glands and in the partially purified extracts.

(6) D. Morse and B. C. Horecker, *Anal. Biochem.*, 14, 429 (1966).

I. Putter, E. A. Kaczka, R. E. Harman, E. L. Rickes
A. J. Kempf, L. Chaiet, J. W. Rothrock, A. W. Wase, F. J. Wolf
Merck Sharp & Dohme Research Laboratory
Rahway, New Jersey
Received July 24, 1967

Oxidative Coupling Using Copper(I) Ate Complexes[1]

Sir:

The oxidative coupling of acetylenic copper compounds provides a useful method of forming carbon–carbon bonds under mild conditions.[2] Extensions of this coupling reaction to hydrocarbons less acidic than terminal acetylenes have been limited, primarily due to the practical difficulties involved in generating the requisite organocopper species *in situ* in neutral or weakly basic solutions. We wish to report that organolithium and -magnesium reagents, in which the availability of the required carbanionic site is not determined by the ease of hydrogen abstraction, can be coupled in synthetically useful yields by conversion to copper(I) ate complexes, followed by oxidation with molecular oxygen or with copper(II) salts.[3]

$$2C_4H_9Li + [ICuP(C_4H_9)_3]_4 \xrightarrow[-78°]{THF} \underset{\mathbf{1}}{(C_4H_9)_2CuLi} \xrightarrow[-78°]{O_2} C_8H_{18} \quad (1)$$

In a typical experiment, lithium di-*n*-butylcuprate (**1**) was prepared by reaction of 1 equiv of tetrakis[iodo(tri-*n*-butylphosphine)copper(I)][4] in tetrahydrofuran (THF) at −78° with 2 equiv of commercial *n*-butyllithium. Treatment of the resulting colorless or pale yellow solution at −78° with excess oxygen resulted in immediate reaction and formation of a dark precipitate. After the reaction mixture had been stirred vigorously for several minutes, hydrolysis and analysis indicated the presence of octane (84%), 1-butene (14%), and 1-butanol (5%).[5] Representative results obtained on oxidation of other ate complexes under similar conditions are given in Table I.

Table I. Oxidative Coupling of Copper(I) Ate Complexes (Eq 1)[a]

Starting organometal compd	Product	Yield, %[b]
n-Butyllithium	Octane	84
n-Butylmagnesium bromide	Octane	67
sec-Butyllithium	3,4-Dimethylhexane	82
t-Butyllithium	2,2,3,3-Tetramethylbutane	14
Phenyllithium	Biphenyl	75
trans-1-Propenyllithium	*trans,trans*-2,4-Hexadiene	78
Phenylethynyllithium	1,4-Diphenylbutadiyne[c]	67
Butane-1,4-di(magnesium bromide)	Cyclobutane[d]	25
Pentane-1,5-di(magnesium bromide)	Cyclopentane	30
Octane-1,8-di(magnesium bromide)	Cyclooctane	0
Phenyllithium + *n*-butyllithium (1:1)	Octane	33
	Biphenyl	28
	n-Butylbenzene	33
Neophyllithium	2,5-Dimethyl-2,5-diphenylhexane	88

[a] Unless otherwise indicated, all reactions were carried out in THF solution at −78° under an inert atmosphere using oxygen as oxidant. Concentration of ate complex ranged from 0.05 to 0.2 *N*. [b] Yields were determined by quantitative vapor phase chromatography; isolated yields in preparative-scale reactions were 10–20% lower. [c] Oxidation at 15°. [d] No cyclooctane or cyclododecane could be detected in the reaction mixtures.

This reaction sequence seems to be applicable to the coupling of primary alkyl, secondary alkyl, vinyl, and aryl groups; in our hands tertiary alkyl groups have given poor yields of dimeric products.[6] Oxidation of mixed ate complexes, obtained by addition of 1 equiv each of two different lithium reagents to 1 equiv of copper(I) salt, gives mixtures of products.[7] The use of THF and dimethoxyethane as solvents results in appreciably higher yields of coupled products than diethyl ether or hydrocarbons. Organolithium compounds give somewhat higher yields of dimers than do the corresponding Grignard reagents.

Although our understanding of the detailed course of this reaction is still incomplete, several observations permit a description of the general features of its mechanism. First, the products of the oxidations provide convincing evidence against long-lived free alkyl radicals

(1) Supported in part by the National Science Foundation.
(2) (a) G. Eglinton and W. McCrae, *Advan. Org. Chem.*, 4, 225 (1963); (b) F. Bohlmann, H. Schonowsky, E. Inhoffen, and G. Grau, *Ber.*, 97, 794 (1964).
(3) W. Tochtermann, *Angew. Chem. Intern. Ed. Engl.*, 5, 351 (1966), and G. Wittig, *Quart. Rev.* (London), 20, 191 (1966), have provided reviews of the properties and reactions of ate complexes.
(4) G. B. Kauffman and L. A. Teter, *Inorg. Syn.*, 7, 9 (1963).
(5) The same yields were observed on oxidation of the more clearly defined ate complex obtained by treatment of a suspension of halide- and phosphine-free *n*-butylcopper(I) at −50° in THF with *n*-butyllithium.
(6) In practice, thermal decomposition provides a more convenient method of coupling vinylic and aromatic copper(I) compounds than oxidation of ate complexes: G. M. Whitesides and C. P. Casey, *J. Am. Chem. Soc.*, 88, 4541 (1966).
(7) This observation is in agreement with the rapid intermolecular exchange observed by nmr spectroscopy for the methyl groups of lithium dimethylcuprate and methyllithium: H. O. House, W. L. Respess, and G. M. Whitesides, *J. Org. Chem.*, 31, 3128 (1966).

as reaction intermediates. Specifically, the oxidation of lithium dineophylcuprate is unaccompanied by the 1,2-aryl migration characteristic of free neophyl radicals, even when carried out at room temperature.[8] In addition, the oxidation of lithium di-*trans*-1-propenylcuprate yields *trans,trans*-2,4-hexadiene without loss of stereochemistry around the olefinic bonds; we have argued previously that this stereochemical result is incompatible with free propenyl radicals as reaction intermediates.[6] Similarly, the yield of butanol observed in the oxidation of **1** is much smaller than that expected from a reaction which generates free butyl radicals in a solution containing oxygen.

Second, uncomplexed butylcopper(I) can be isolated in moderate yield from incomplete oxidation of **1**. Hence, butylcopper(I) appears to be an intermediate formed rapidly in the initial stages of oxidation, which is itself oxidized in a subsequent step.[9] Examination of the oxidation of butylcopper(I) under these conditions indicates that all of the 1-butene and butanol formed in the oxidation of **1** could be accounted for by its oxidation and suggests that the *initial* oxidation of **1** yields octane and butylcopper(I) quantitatively.

Third, a wide variety of materials other than oxygen are effective oxidants in these reactants. For example, the yields of octane obtained from **1** by oxidation with nitrobenzene, $Cu(II)Cl_2 \cdot TMEDA$, or oxygen are equal.[10] Hence, it seems unlikely that the oxidizing agent is involved in the production of dimer in any capacity other than that of electron acceptor.

These observations, taken together, make an initially formed di-*n*-butylcopper(II), which rapidly disproportionates or further reacts to *n*-butylcopper(I) and octane, an attractive intermediate in the initial oxidation of **1**. Further evidence supporting this proposal will be presented in later papers.

(8) For a review of recent work, see R. Kh. Freidlina, *Advan. Free Radical Chem.*, 1, 211 (1965).
(9) Similar observations have been made in Glaser couplings.[2a]
(10) Even benzophenone will oxidize 1 to octane (in 25% yield); however, these other oxidizing agents produce lower yields of dimers than does oxygen in oxidation of secondary and alkynyl ate complexes.
(11) (a) National Institutes of Health Predoctoral Fellow, 1966–1967; (b) National Science Foundation Predoctoral Fellow, 1963–1967; (c) E. B. Hershberg Fellow, 1965–1966.

George M. Whitesides, Joseph SanFilippo, Jr.[11a]
Charles P. Casey,[11b] **Edward J. Panek**[11a,c]
Department of Chemistry, Massachusetts Institute of Technology
Cambridge, Massachusetts 02139
Received June 28, 1967

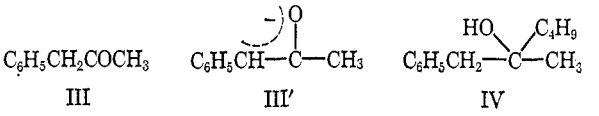
1,3-Dicarbanions of Phenylacetone and Some Other Multiple Anions[1]

Sir:

A β-diketone such as acetylacetone or benzoylacetone can be converted by 2 equiv of potassium amide in liquid ammonia to its 1,3-dicarbanion I″, as evidenced by condensations at the terminal position with electrophilic compounds[2] and by nmr.[3] Similarly, dibenzyl ketone can be converted to its 1,3-dicarbanion II″ by this base.[4]

$RCO\bar{C}HCO\bar{C}H_2$ (I″) $\qquad$ $C_6H_5\bar{C}HCO\bar{C}HC_6H_5$ (II″)

No other monoketone, however, appears to have been converted satisfactorily to a 1,3-dicarbanion by an alkali amide. Phenylacetone (III) is readily converted to its monoanion III′ by 1 equiv of potassium amide in liquid ammonia but, apparently, no appreciable secondary ionization of a methyl hydrogen occurs with excess of this base.[4] Although *n*-butyllithium in ether or tetrahydrofuran (THF) is, potentially, a much stronger base than an alkali amide, the successful usage of this organolithium reagent as a base to ionize phenylacetone is precluded by our observation that this reagent attacks preferentially the carbonyl group of the ketone to form carbinol IV.

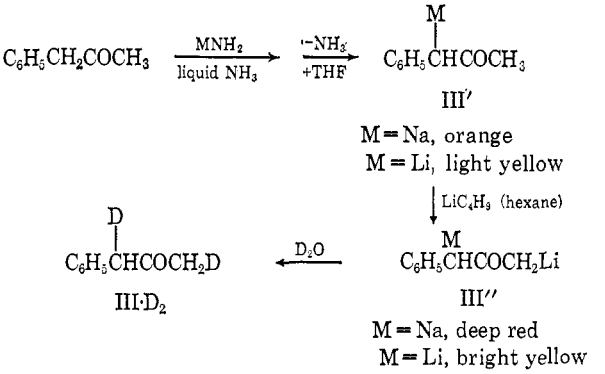


III $\qquad$ III′ $\qquad$ IV

Since the initial reaction of phenylacetone with the alkali amide to form the monoanion III′ should nullify a subsequent attack at the carbonyl group by *n*-butyllithium, it seemed possible that the use of 1 equiv of an alkali amide followed by one of the much stronger organolithium reagent might lead to the formation of the desired 1,3-dicarbanion. This was realized in the present investigation.

The method involved addition of the ketone III in tetrahydrofuran (THF) to slightly more than 1 equiv of sodium amide or lithium amide in liquid ammonia, replacement of the ammonia with THF, and addition of slightly more than 1 equiv of *n*-butyllithium in hexane at room temperature. The formation of the 1,3-dialkali salt III″ was indicated by production of a rather intense color (the particular color being dependent on M) and established by deuteration (Scheme I).

Scheme I



The structure of the deuterated ketone III-D_2 was supported by its nmr spectrum which showed 95–98% of one deuterium atom/molecule at the terminal methyl group and 100% of one deuterium atom/molecule at the methylene group. In a blank experiment, no deuterium was acquired by phenylacetone from deuterium oxide in the presence of sodium or lithium deuterioxide.

The 1,3-dialkali salt III″ (M = Na or Li) underwent terminal condensations with anisaldehyde and chalcone

(1) Supported by National Science Foundation Grant No. GP 6486.
(2) C. R. Hauser and T. M. Harris, *J. Am. Chem. Soc.*, **80**, 6360 (1958).
(3) M. L. Miles, C. G. Moreland, D. M. von Schriltz, and C. R. Hauser, *Chem. Ind.* (London), 1966, 2098.
(4) C. R. Hauser and T. M. Harris, *J. Am. Chem. Soc.*, 81, 1154 (1959).