mild acidic cleavage produced the aldehyde **16** (X = H) in 75% yield (3450, 1690 cm^{-1}; τ 9.8 CHO). The difficulty encountered in the hydrolysis of **13** was circumvented by chromic acid oxidation of **13** to the ketone oxazine **14** (80%; mp 99-101; 1640 and 1660 cm^{-1}) which proceeded without damage to the oxazine ring. Hydrolysis of **14** in aqueous acid afforded *m*-(*p*-anisoyl)-benzoic acid **15** (X = COC_6H_4OMe) in good yield (80%, mp 189-190°; ir (KBr) 3200-3500, 1680, 1650, and 1590 cm^{-1}; nmr (TFA) τ 5.98 (s, 3, CH_3O), 1.2-3.0 (m, 8,ArH)). The formation of this product now allows a route to compounds inaccessible by Friedel-Crafts acylations. Studies to realize the full potential of this synthesis are under active investigation.[10]

Acknowledgments. Financial assistance from the Petroleum Research Fund, administered by the American Chemical Society, Ciba Pharmaceutical Co., Hoffman-LaRoche, and Warner-Lambert Research Institute is gratefully acknowledged. We are indebted to Miss Patricia Hodapp for technical assistance.

[10] All new compounds gave satisfactory combustion analyses.

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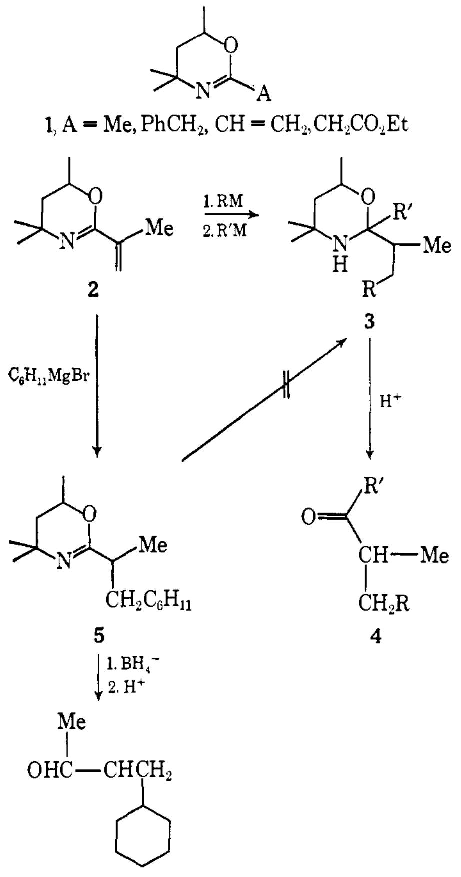
Syntheses *via* Dihydro-1,3-oxazines. VII. A Simple Synthesis of Unsymmetrical Ketones

Sir:

The versatility of 5,6-dihydro-1,3-oxazines (**1**) as useful precursors to aldehydes containing two[1] or three[2] additional carbon atoms has recently been demonstrated. We wish to report that the readily accessible[3] 2-isopropenyl oxazine **2** has now been shown to react with Grignard or organolithium reagents in tetrahydrofuran to produce the 2,2-dialkyl tetrahydro-1,3-oxazines (**3**) which are precursors to unsymmetrical α-methyl ketones **4**. The major feature of this new reaction centers around the fact that the organometallic (RM) reagents are added in a single sequence[4] to produce **3**. If R = R′, then the dialkylated derivative, **3**, may be formed by merely introducing 2.0-2.5 equiv of the Grignard or organolithium reagent into a solution of **2** in THF. If R and R′ are different, then the initial alkyl or aryl metallic is added followed by addition of the second alkyl or aryl metallic after approximately 1 hr. The isolation of **3** is simply a matter of dilution of the reactants with water, extraction of the product with ether, and cleavage of the crude product to **4** using aqueous oxalic acid (reflux, 2 hr). The ketones thus obtained were formed in good yields (Table I) on a preparative scale (4-10 g).[5] The nature of the *initially introduced*



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organometallic appears to be independent of the reaction requirements; however, the second step is limited to primary alkyl or phenyl metallics. Thus **3** will only form if R′M is not isopropyl, *sec*-butyl, cyclohexyl, or *t*-butyl. In these cases only monoalkylation occurs, as was observed when 2.5 equiv of cyclohexylmagnesium bromide was treated with **2**. The oxazine **5** was formed in 98% yield, which upon reduction and acid cleavage[1]

Table I. Formation of α-Methyl Ketones (**4**)

Entry	RM	R′M	% **4**, overall[a]
1	*n*-BuMgBr	*n*-BuMgBr	79
2	*t*-BuLi	MeLi	73[b]
3	*t*-BuLi	EtMgBr	67
4	*t*-BuLi	*n*-BuMgBr	77
5	PhMgBr	PhMgBr	47[c]
6	EtMgBr	EtMgBr	67
7	*n*-PrMgI	*n*-PrMgI	80
8	$C_6H_{11}MgBr$	MeLi	82
9	$C_6H_{11}MgBr$	$NaBH_4$	80[d]

[a] All products were obtained in pure state and gave satisfactory elemental analysis, mass spectra, and derivatives (2,4-DNP or semicarbazone). [b] M. F. Ansell, W. J. Hickenbottom, and A. A. Hyatt, *J. Chem. Soc.*, 1592 (1955), report 2,4-DNP, mp 65°; found mp 64-65°. [c] L. I. Smith and J. R. Holum, *J. Amer. Chem. Soc.*, **78**, 3417 (1956), report 2,4-DNP, mp 134°; found mp 133°. [d] Overall yield of aldehyde **6**; 2,4-DNP, 146-148°.

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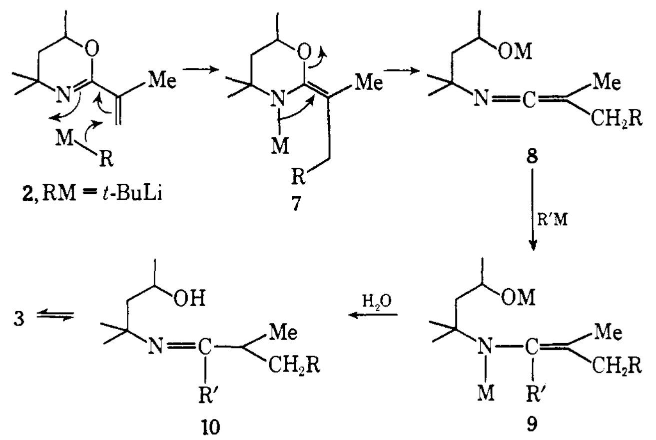
[1] H. W. Adickes, I. R. Politzer, and A. I. Meyers, *J. Amer. Chem. Soc.*, 91, 2155 (1969), and other references cited therein; preparative procedures have appeared, *Org. Proc. Prep.*, **1**, 193 (1969); **1**, 213 (1969).

[2] A. I. Meyers and A. C. Kovelesky, *Tetrahedron Lett.*, 1783 (1969).

[3] Prepared from methacrylonitrile and 2,4-dimethyl-2,4-pentanediol according to J. J. Ritter and E. J. Tillmans, *J. Org. Chem.*, **22**, 839 (1957). Commercially available from Columbia Organic Chemicals, Columbia, S. C.

[4] Addition to the isopropenyl oxazine may be performed at temperatures between 25 and −78° with essentially the same results. This aspect of the process provides unusual latitude with respect to the type of organometallic employed.

[5] It is interesting to note that the vinyl derivative **1** does not display the ability to doubly alkylate in the manner shown by **2**. Similar reaction conditions result in complete polymerization of **1**. This is probably due to the instability of the corresponding ketenimine **8** (Me = H).



produced the aldehyde **6** in 80% over-all yield (Table I).[6] Although the cyclohexyl group adds but once, it does not deter the use of a second equivalent of a less bulky reagent to form the ketone (entry 8, Table I).

This process does not involve a simple addition to the C=N link of the oxazine **2** since treatment of **5** with RMgX or RLi failed to produce **3** even under forcing conditions.[7] The mechanism of the double alkylation of **2** leading to **3** was shown to involve a subtle *alkylation-ring cleavage-alkylation-ring closure* sequence (**7**-**8**-**9**-**10**-**3**). Confirmation of this pathway was gathered when 1.0 equiv of *t*-butyllithium was added to **2** and the solvent evaporated leaving a hygroscopic salt, which proved to be **8** (M = Li, R = *t*-Bu), ir (mull) 2010 cm^{-1} (very intense).[8] Addition of **8** to water converted it to the *t*-butyl analog of **5**. It, therefore, becomes clear how Grignards and organometallics add to the "oxazine" producing **9**,[9] which upon hydrolysis forms the imine **10**, the tautomer of the cyclic tetrahydro-1,3-oxazine **3**. Further studies on this novel ketone synthesis are in progress with an aim toward preparing cyclic, additional α-alkyl, and optically active ketones.[10]

Acknowledgments. Financial assistance from the Petroleum Research Fund, administered by the American Chemical Society, Ciba Pharmaceutical Co., Hoffman-LaRoche, and Warner-Lambert Research Institute is gratefully acknowledged.

(6) This product, as well as others prepared in this report containing related structures, complements nicely the aldehyde and ketone synthesis described by H. C. Brown *Accounts Chem. Res.*, **2**, 65 (1969). The products obtained *via* the oxazine route are those which the Brown synthesis would form with difficulty due to the complexity of the olefins required.

(7) The dihydro-1,3-oxazine ring **1**, **2**, or **5** has been found to be totally inert to the Grignard reagent after heating to reflux in ether, benzene, and THF for prolonged periods. This, therefore, represents a new carboxylic acid derivative stable to the Grignard reagent and may be employed as a unique protecting group (A. I. Meyers, I. R. Politzer, B. K. Bandlish, and G. R. Malone, *J. Amer. Chem. Soc.*, **91**, 5886 (1969).

(8) C. L. Stevens and J. C. French, *ibid.*, **76**, 4401 (1954) reported that a completely aliphatic-substituted ketenimine showed strong absorption at 2045 cm^{-1}.

(9) Ketenimines are well known to react in the above fashion with Grignards and organolithium reagents (C. L. Stevens and R. J. Gasser, *ibid.*, **79**, 6057 (1959)).

(10) Complete experimental details will be sent to anyone upon request.

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Further Experiments Pertaining to the Ground State of Cyclobutadiene

Sir:

Theoretical calculations continue to offer conflicting results as to the nature of the ground state of cyclobutadiene.[1-3] While there appears to be general agreement that a structure having a square arrangement of carbon atoms would be more stable in its triplet rather than singlet electronic state, calculations differ as to whether this triplet state is more[1] or less stable[2,3] than a singlet state having a rectangular configuration. There is evidence that cyclobutadiene can be liberated from its iron tricarbonyl complex and although the amounts which have been collected and detected separately are extremely small, nonetheless these experiments indicate that the molecule is at least thermodynamically stable, though of course extremely reactive.[4] It has been previously shown that oxidative decomposition of cyclobutadieneiron tricarbonyl in the presence of reagents with which cyclobutadiene would be expected to add does indeed lead to these adducts and frequently in high yield. Thus decomposition of the complex in the presence of such dienophiles as dimethyl maleate,[5] dimethyl fumarate,[5] benzoquinone,[6] dibromobenzoquinone,[6] cyclobutadiene,[5] or benzocyclobutadiene[7] or with dienes such as cyclopentadiene,[5] diethoxycyclopentadiene,[8] or thiapyrone dioxide[9] leads to adducts which have the stereochemistry that would be expected on the basis of normal Diels-Alder rules of addition. On the basis of these results we have suggested that cyclobutadiene possesses a singlet ground state. In the present paper we offer further evidence that these *in situ* experiments give products resulting from the reaction of cyclobutadiene itself and provide added data pointing to a singlet nature for the ground state.

Although other diene-iron tricarbonyl complexes, *e.g.*, butadieneiron tricarbonyl, readily shed the ligands upon oxidation of the Fe^0 in the complex to Fe^{2+},[10] nonetheless in the present instance there would seem to be several possible modes of reaction which could proceed prior to the liberation of *free* cyclobutadiene which should be considered. In our opinion the four most serious alternatives are (a) direct reaction between the reagent, *e.g.*, dimethyl maleate, and the cyclobutadiene complex, (b) replacement of a CO ligand by maleate followed by intramolecular addition to the coordinated cyclobutadiene ligand, (c) replacement of CO by maleate and then addition to the coordinated cyclobutadiene during the oxidation, and (d) external attack by maleate on some oxidized form of the complex having the cyclobutadiene ligand still attached to the iron atom.

(1) N. L. Allinger, C. Gilardeau, and L. W. Chow, *Tetrahedron*, **24**, 2401 (1968).

(2) M. J. S. Dewar and G. J. Gleicher, *J. Amer. Chem. Soc.*, **87**, 3255 (1965).

(3) R. J. Buenker and S. D. Peyerimhoff, *J. Chem. Phys.*, **48**, 354 (1968).

(4) L. Watts, J. D. Fitzpatrick, and R. Pettit, *J. Amer. Chem. Soc.*, **87**, 3253 (1965); W. Tyerman, M. Kato, P. Kebarle, S. Masamune, O. Strausz, and H. Gunning, *Chem. Commun.*, 497 (1967).

(5) L. Watts, J. D. Fitzpatrick, and R. Pettit, *J. Amer. Chem. Soc.*, **88**, 623 (1966).

(6) J. C. Barborak, L. Watts, and R. Pettit, *ibid.*, **88**, 1328 (1966).

(7) W. Merk and R. Pettit, *ibid.*, in press.

(8) J. C. Barborak and R. Pettit, *ibid.*, **89**, 3080 (1967).

(9) L. A. Paquette and L. D. Wise, *ibid.*, **89**, 6659 (1967).

(10) R. Pettit and G. F. Emerson, *Advan. Organometal. Chem.*, **1**, 31 (1964).