bromide, 874-98-6; 3,5-dimethoxybenzyl bromide, 877-88-3; 4-methoxybenzyl bromide, 2746-25-0; benzyl bromide, 100-39-0; 2-methylbenzyl bromide, 89-92-9.

James M. Hook, Lewis N. Mander*

Research School of Chemistry
Australian National University
Canberra, ACT 2600, Australia

Received October 30, 1979

Naphthalenes and Biphenyls via a Novel Reaction of *N,N*-Dimethylformamide Dimethyl Acetal

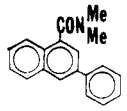
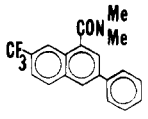
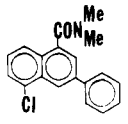
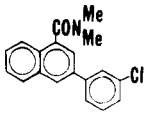
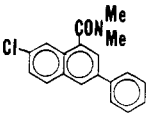
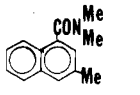
Summary: In the presence of *N,N*-dimethylformamide dimethyl acetal at elevated temperatures, certain methylene ketones react to form *N,N*-dimethyl-1-naphthalenecarboxamides, while diketones react to form *N,N,O*-trimethylsalicylamides.

Sir: Since the initial report by Meerwein et al. on the synthesis and properties of formamide acetals[1] and their development for use as alkylating and formylating agents,[2] numerous transformations of organic substrates employing these compounds have appeared in the literature.[3] We report here an unusual conversion effected on certain substituted acetone derivatives by *N,N*-dimethylformamide dimethyl acetal (A) which affords aromatic rings as end products.

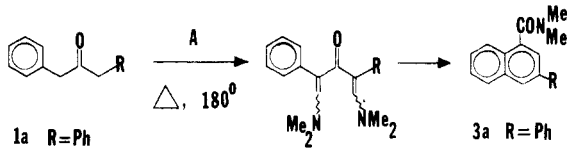
Our initial aim was the conversion of 1,3-diphenylacetone (**1a**) to the bis-enaminone **2a** by treatment with acetal A.[4] Indeed, **2a** may be formed from **1a** in good yields (70–75% as a mixture of *E* and *Z* components) at reaction temperatures of 110–112 °C (reflux with neat A). However, when we treated **1a** with acetal A at 150–200 °C in a steel autoclave under nitrogen, we obtained in greater than 90% yield[5] compound **3a**: $C_{19}H_{17}NO$ (combustion analysis: C, 82.45; H, 6.08; N, 5.48); mp 136–138 °C.[6] An X-ray crystallographic analysis[7] established the structure of **3a** to be *N,N*-dimethyl-3-phenyl-1-naphthalenecarboxamide. Spectrographic data were consistent with this structure.

The conversion of **1** to **3** represents a novel transformation of 1,3-diaryl- and 1-aryl-3-alkylacetones to naphthalene derivatives (Scheme I), which upon further examination has been shown to be general[8] (Table I). It appears that the reaction proceeds by the intervention of intermediates such as **2**.[10]

Table I

(1) R	(3)	% Yield	mp °C
a. 	a. 	95	136–138
b. 	b. 	50[9]	107–108
c. 	c. 	8.9	113–115
	d. 	0.89	142–143
	e. 	1.1	145–147
d. Me	f. 	90	74–76

Scheme I



In an effort to delineate the scope of this reaction, we performed experiments on the diketones **1e** and **1f**. Treatment of either **1e** or **1f**[11] (Scheme II) with acetal A did not give naphthalenes but instead afforded in moderate yields the 4-methoxybiphenyl-3-carboxamides **4a** and **4b**, respectively. The structure of **4a** was established by an alternate synthesis from authentic methyl 4-hydroxybiphenyl-3-carboxylate (Scheme II).[12] No benzenoid nucleus could be isolated, however, from the reaction of acetalacetone with A at 180 °C. At lower temperatures, the expected enaminedione was formed.

We also observed aromatic ring formation upon treatment of (phenoxyacetyl)diethylstyrylamine (**5**)[4] with A at 180 °C. The phenoxynaphthylamide **3g** was isolated after column chromatography (silica gel, 25% EtOAc/toluene) as a glass in 26% yield. In a similar manner, 1-phenoxy-2,4-pentanedione (**6**)[13] was converted to the phenoxy-

(1) H. Meerwein, P. Borner, O. Fuchs, H. J. Sasse, H. Schrodt, and J. Spille, *Chem. Ber.*, **89**, 2060 (1956); H. Meerwein, W. Florian, N. Schön, and G. Stopp, *Justus Liebigs Ann. Chem.*, **641**, 1 (1961).

(2) H. Bredereck, F. Effenberger, and G. Simchen, *Angew. Chem.*, **73**, 493 (1961); H. Bredereck, G. Simchen, S. Rebsdat, W. Kantlehner, P. Horn, R. Wahl, H. Hoffmann, and P. Grieshaber, *Chem. Ber.*, **101**, 41 (1968).

(3) R. F. Abdulla and R. S. Brinkmeyer, *Tetrahedron*, **35**, 1675–1735 (1979).

(4) R. F. Abdulla, T. L. Emmick, and H. M. Taylor, *Synth. Commun.*, **7**, 305 (1977); R. F. Abdulla, K. H. Fuhr, and H. M. Taylor, *ibid.*, **7**, 313 (1977).

(5) These refer to *isolated* yields of *chromatographically homogeneous* materials.

(6) **3a**: M^+ *m/e* 275; IR (Nujol) $\tilde{\nu}$ 1635 (C=O, amide) cm^{-1}; NMR ($CDCl_3$) δ 7.1–8.1 (m, 12 H), 2.8 (s, 3 H), 3.2 (s, 3 H), T_c = 90 °C (s, 6 H); UV λ_{max}^{EtOH} (ϵ) 211 (36 756), 253 (52 267), 288 (11 330) nm. All of the compounds reported in this communication were fully characterized by satisfactory combustion analysis and spectrography.

(7) X-ray analysis was performed by Drs. N. D. Jones and M. O. Chaney of the Physical Chemistry Research Department of Eli Lilly and Co.

(8) One vacant ortho position on one aromatic ring of the substituted acetone is a necessary condition for naphthalene formation.

(9) Other isomers were detected by NMR spectroscopy in the crude reaction product, but their isolation by column chromatography proved unsuccessful.

(10) This conclusion is based on the cyclization of **2a** (R = Ph) upon thermolysis at 200 °C under nitrogen in a stainless steel autoclave.

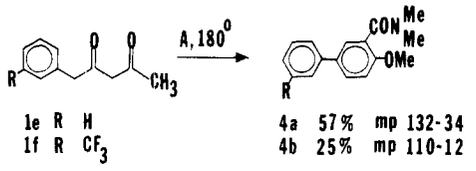
(11) **1e** and **1f** were prepared by using sodium amide/dry ether in a Claisen condensation of acetone with ethyl phenylacetate and with ethyl [*m*-(trifluoromethyl)phenyl]acetate, respectively. See also H. Mühlemann, *Pharm. Acta Helv.*, **24**, 356 (1949), for the synthesis of **1e**.

(12) Obtained from the Organic Compounds File of Eli Lilly and Co.

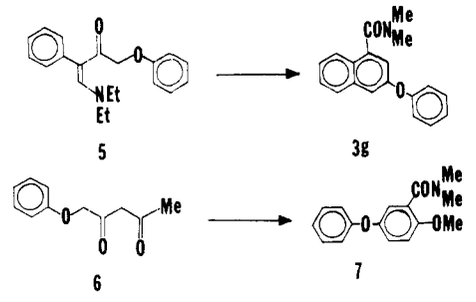
(13) This material was prepared by Claisen condensation of acetone with methyl phenoxyacetate in a manner analogous to that of ref 11 in 61.5% yield; bp 92–94 °C (0.5 mm).

0022-3263/80/1945-1724$01.00/0

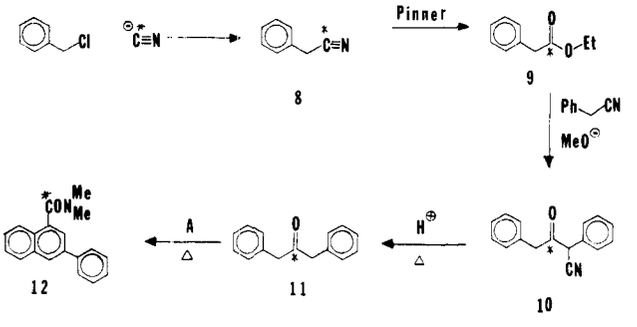
Scheme II



Scheme III



Scheme IV



benzamide (**7**) in 10% yield. These transformations are shown in Scheme III.

Having demonstrated the generality of the conversion, although conceding poor yields in several instances, we next directed our attention to the mechanism of these unusual processes. The question of the origin of the carbonyl group in the naphthalenecarboxamides had intrigued us from the very beginning of our investigation. Therefore the ketone carbonyl was labeled in compound **1a** with ^{13}C, and its fate was observed during the transformation with acetal A. Scheme IV shows the synthesis of 1,3-diphenyl-2[^{13}C]propanone (**11**) from benzyl chloride and potassium [^{13}C]cyanide. The intermediate phenylacetonitrile (**8**) was converted by a standard Pinner synthesis to the labeled phenylacetate **9**. Acylation of unlabeled phenylacetonitrile with **9** in toluene/sodium methoxide gave the keto nitrile **10**, which was converted to **11** with a glacial acetic acid/sulfuric acid mixture at 110 °C in 2 h. Upon subjecting **11** to the aromatization reaction with acetal A, we obtained the naphthalene derivative **12**. ^{13}C NMR spectroscopy showed enrichment of the carboxamide carbonyl group.[14] Therefore the carbonyl group of the substituted acetone **11** terminated as the carboxyl group in the product carboxamide **12**, and a substantial molecular rearrangement had occurred. The details of the mechanism of these transformations are under investigation.

In summary, we have described a novel aromatic ring synthesis, by which naphthalenes, biphenyls, and diphenyl ethers, difficult to prepare by conventional syntheses, may conveniently be made *in one step*, from a suitably substituted acetone derivative and *N,N*-dimethylformamide dimethyl acetal.

Acknowledgment. We thank Professor E. C. Taylor of Princeton University and Professor J. E. Baldwin of Oxford University, England, for critical evaluation of this work.

Registry No. 1a, 102-04-5; **1b**, 59756-57-9; **1c**, 73178-50-4; **1d**, 1007-32-5; **2a**, 73178-51-5; **3a**, 73178-52-6; **3b**, 73178-53-7; **3c**, 73178-54-8; **3d**, 73178-55-9; **3e**, 73178-56-0; **3f**, 73178-57-1; **4a**, 73178-58-2; **4b**, 73178-59-3; **5**, 73178-60-6; **6**, 18045-26-6; **7**, 73178-61-7; *N,N*-dimethylformamide dimethyl acetal, 4637-24-5.

Supplementary Material Available: Schemes V–VII, speculative mechanisms for naphthalene and biphenyl ring synthesis (3 pages). Ordering information is given on any current masthead page.

R. F. Abdulla,* K. H. Fuhr, R. P. Gajewski
R. G. Suhr, H. M. Taylor, P. L. Unger

Lilly Research Laboratories
Division of Eli Lilly and Company
Greenfield, Indiana 46140

Received October 12, 1979

Thermal Rearrangement of 1-(Carbomethoxy)-6-*exo*-(1-alkenyl)bicyclo[3.1.0]hex-2-ene Systems. A Convenient Synthesis of Functionalized Bicyclo[3.2.1]octa-2,6-dienes

Summary: Thermal rearrangement of the substituted bicyclo[3.1.0]hex-2-enes **22–25** affords, in quantitative yields, the corresponding bicyclo[3.2.1]octa-2,6-dienes **26–29**, respectively. On the other hand, thermolysis of 1-(carbomethoxy)-6-*exo*-vinylbicyclo[3.1.0]hex-3-en-2-one (**34**) gives 1-(carbomethoxy)bicyclo[3.2.1]octa-2,6-dien-8-one (**35**) (73% yield).

Sir: The thermal $_{\pi}2_s + _{\sigma}2_s + _{\pi}2_s$ (Cope) rearrangement of *endo*-6-vinylbicyclo[3.1.0]hex-2-ene (**1**) to afford bicyclo[3.2.1]octa-2,6-diene (**2**) is a very facile process (half-life ~ 1 day at 25 °C).[1] In contrast, the exo isomer **3**, like other *trans*-divinylcyclopropane systems, is stable at ambient temperatures. Nevertheless, thermolysis of **3** at elevated temperatures (e.g., 195 °C)[2] also affords cleanly the bicyclic diene **2**. The latter transformation has been shown[2] to proceed via a one-center epimerization at C_6, followed by a normal Cope rearrangement (**3** → **1** → **2**).

Interestingly, the rearrangement of 6-vinylbicyclo[3.1.0]hex-2-ene systems has received relatively little attention from a synthetic point of view.[3] Since many natural products incorporate into their structures the bicyclo[3.2.1]octane carbon skeleton, we have recently begun a study aimed at the synthesis of functionalized bicyclo[3.2.1]octanes via Cope rearrangement of the requisite 6-(1-alkenyl)bicyclo[3.1.0]hex-2-enes. We report herein the results of some of our initial experiments in this area.

(14) ^{13}C NMR spectra were run on a Japan Electron Optics Limited PFT-100 spectrometer and were provided by Dr. D. E. Dorman of the Physical Chemistry Research Department of Eli Lilly and Co.

(1) Cupas, C.; Watts, W. E.; Schleyer, P. von R. *Tetrahedron Lett.* **1964**, 2503. Brown, J. M. *Chem. Commun.* **1965**, 226.
(2) Baldwin, J. E.; Gilbert, K. E. *J. Am. Chem. Soc.* **1976**, *98*, 8283.
(3) (a) Brown, J. M. *Chem. Commun.* **1967**, 638. (b) Klumpp, G. W.; Barick, J. W. F. K.; Veefkind, A. H.; Bickelhaupt, F. *Recl. Trav. Chim. Pays-Bas* **1969**, *88*, 766.

0022-3263/80/1945-1725$01.00/0