

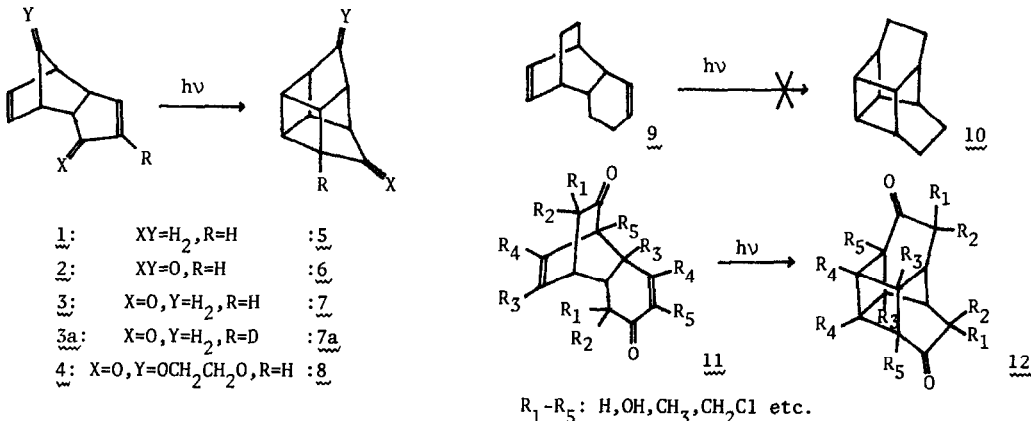
SYNTHESES AND REACTIONS OF CAGE COMPOUNDS VI. SYNTHESIS OF PENTACYCLO[6,3,0,0^{2,7},0^{5,11},0^{6,9}]-UNDECANONES AND PENTACYCLO[6,4,0,0^{2,7},0^{3,10},0^{6,9}]DODECANEDIONES BY DIAZOMETHANE RING EXPANSION

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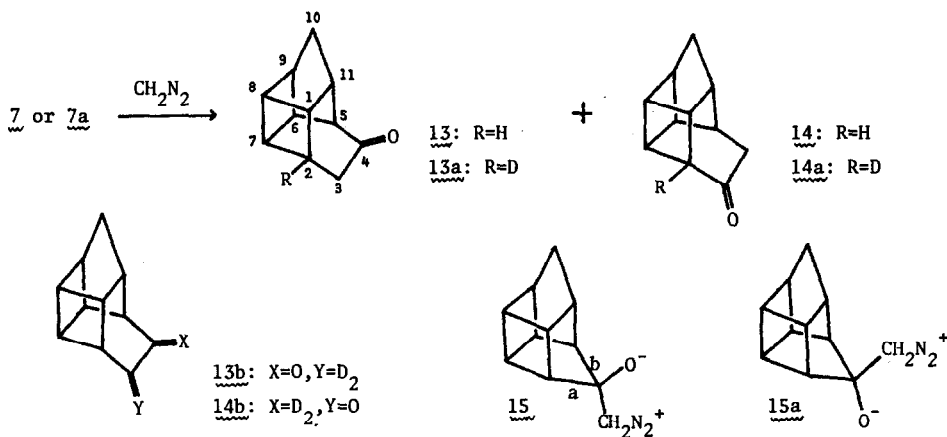
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(Received in Japan 25 August 1975; received in UK for publication 29 September 1975)

On irradiation, cyclopentadiene dimer (1) and its enone derivatives (2,3,4) are converted easily to the corresponding cage compounds, 5, 6, 7 and 8, by intramolecular cycloaddition, whereas the corresponding transformation of a six-membered analog, from cyclohexadiene dimer (9) to 10, is not known.⁵ Recently, the cage system of 10 was synthesized photochemically from cyclohexadienone dimers (11),⁶ and was interestingly found in a natural product.⁷ Another synthesis of this cage system may be provided by ring expansion of 6 with CH₂N₂. It is well known, however, that six-membered ring reacts with CH₂N₂ more rapidly than five-membered ring,⁸ and accordingly it is difficult to synthesize six-membered ketones by this reaction, e.g., cyclopentanone gives primarily cycloheptanone rather than cyclohexanone.⁹ This is also the case for the reaction of bridged bicyclic ketones¹⁰ and usual cage compounds.¹¹ Nevertheless, the reaction of 6-8 can be expected to stop at the six-membered ketone stage, because homologous seven-membered ketones must have a quite large strain due to the cage system including bicyclo[2,2,0]hexane.



Compound 7 was treated with 3 equiv. of CH₂N₂ in ether at 0-5° overnight.¹² Column chromatography on silica gel gave two major fractions: a mixture (45%) of 13 and 14 (ca. 1.5:1 determined by glc) having a novel cage system of pentacyclo[6,3,0,0^{2,7},0^{5,11},0^{6,9}]undecane, and unusual dimeric cage compounds (44%) which will be reported soon. The former mixture was separated into 13 [mp 98°; ν_{Nujol} 1718 cm⁻¹; δ_{CCl₄} 1.53 (s, 2H; C-10 CH₂), 2.00 (qq, 2H, J_{AB} = 20, J_{AX} = 2, J_{BX} = 2.5 Hz; C-3 CH₂); m/e 160 (M⁺), 117 (base), 66 (C₅H₆); semicarbazone mp 206-208° (decomp)] and

Table. Ring Expansion of $\underline{7}$ with CH_2N_2 in the Presence and Absence of MeOH

Time (hr)	Yield (%) ^a				Yield (%) ^b			
	$\underline{7}$	$\underline{11}$	$\underline{12}$	$\underline{11}+\underline{12}^c$	$\underline{7}$	$\underline{11}$	$\underline{12}$	$\underline{11}+\underline{12}^c$
1	85.1	3.5	2.9	43	17.9	38.2	37.7	92.5
3	76.0	7.3	5.6	53.8	16.0	39.3	37.4	91.3
5	69.1	9.0	8.0	55	11.2	45.0	43.2	99.3
24	51.8	12.0	10.6	48.8	4.5	46.8	43.8	94.5

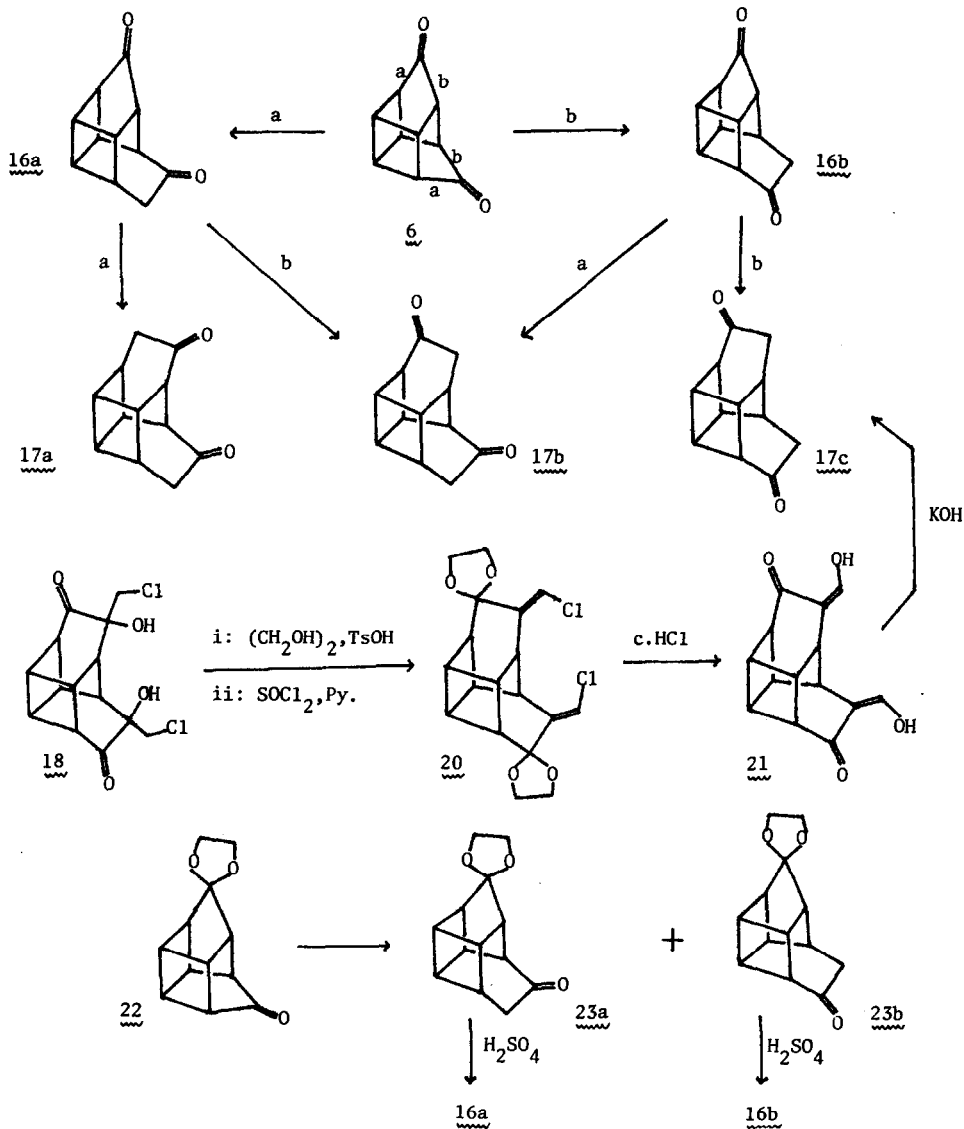
a: An ether solution of $\underline{7}$ (35 mM) with 7 equiv. of CH_2N_2 was allowed to stand in a refrigerator (0-5°). b: The solvent was changed from ether to ether-MeOH (15:1). c: Yield ($\underline{11}+\underline{12}$) based on the consumed $\underline{7}$.

$\underline{14}$ [mp 66-67°; ν_{Nujol} 1718 cm^{-1} ; δ^{GC1} 1.54 (q, 2H, $J_{\text{AB}} = 10.5$ Hz; C-10 CH_2), 2.24 (s, 2H, C-4 CH_2); m/e 160 (M^+), 117 (base), 66 (C_5H_6); semicarbazone mp 202-203° (decomp)] by repeated chromatographies. The structures of $\underline{13}$ and $\underline{14}$ were established by comparing the signals of methylene groups adjacent to the carbonyl groups in their nmr spectra with those of deuterated compounds, $\underline{13a}$, $\underline{13b}$, $\underline{14a}$ and $\underline{14b}$.¹³

In order to learn a more exact feature of the reaction, a diluted ether solution of $\underline{7}$ was treated with a large excess of CH_2N_2 in the presence and absence of MeOH, and the reaction was followed by glc as shown in Table. There are three points of interest. (1) As was expected, neither seven-membered ketones nor epoxides¹⁴ were detected. (2) In the presence of MeOH, no dimeric cage compounds formed, and $\underline{13}$ and $\underline{14}$ were analyzed in 95% yield based on the consumed starting material. (3) No significant difference between the yields of $\underline{13}$ and $\underline{14}$ reflects similar migratory aptitudes of bonds a and b in the zwitterion intermediate ($\underline{15}$).¹⁵ Although there are many reports on various steric factors^{10,11,14,16} which govern migratory aptitudes with somewhat complication,⁸ careful inspection of models indicates that the bonds a and b in $\underline{15}$, not $\underline{15a}$, are almost equivalent sterically.

A solution of $\underline{6}$ (75 mM) and CH_2N_2 (8 equiv.) in ether-MeOH (15:1) was allowed to stand in a refrigerator (0-5°) for 8 hr. Chromatography on silica gel gave three double ring expansion

products, 17a (20.3%, mp 200-205°), 17b (43.2%, mp 90-92°) and 17c (15%, mp 170-172°). Their spectral and analytical data gave no information to distinguish between their structures, however, the ratio in their yields (ca. 1:2:1) may enable us to determine the structure of 17b which was confirmed by the isolation of single expansion products (16a, 16b) and their conversion to 17b. An ether solution of 6 (0.47 M) was treated with 1.2 equiv. of CH_2N_2 for 3.5 hr to give 16a (15.6%, mp 156-159°) and 16b (8.3%, mp 166-171°).¹⁷ The treatment of 16a with a large excess of CH_2N_2 gave 17a and 17b, and similarly 16b gave 17b and 17c in good yield. The structure of 17c was determined by an alternative synthesis. Compound 18⁴ was converted by the usual method into a ketal (19) [98%, mp 237-238° (decomp)], which was dehydrated to 20 (67%, mp 176-177°) by the



treatment with SOCl_2 in pyridine at room temp for 4 days. Compound 20 was then hydrolyzed with conc HCl to 21 [90.3%, mp 169-171° (decomp)], which gave 7c (76.3%) by the treatment with 5% KOH in refluxing benzene- H_2O (1:1). The structures of 16a, 16b, 17a were then assigned from the relation indicating in the upper half of the foregoing scheme.

Finally, 16a and 16b were also synthesized from a mono-ketal derivative of 6 (22)⁴ by the ring expansion to 23a and 23b, followed by their hydrolysis with 65% H_2SO_4 at room temp.

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- (12) Concentration of 7 was 0.78 M. The reaction proceeded relatively rapidly and after 3 hr the starting material almost disappeared.
- (13) Compounds 13 and 14 were treated with NaOMe in MeOD at room temp for several days to give 13b and 14b, respectively, with the loss of the original methylene signals. Compound 3 was next deuterated similarly for 30 min to yield 3a which was irradiated to give 7a. Ring expansion of 7a gave 13a and 14a. In the nmr spectrum of 13a, the methylene signal changed from the two-quartet to a quartet, whereas the signal in 14a remained unchanged.
- (14) Cf. T. Gibson, J. Org. Chem., 37, 700 (1972).
- (15) The intermediate may be formed by addition of CH_2N_2 from the less hindered side. Cf. reference 3.
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- (17) The yields of recovered starting material 6 and products 16a and 16b as determined by glc were 43, 17.5 and 11.9%, respectively.