

## A CONVENIENT SYNTHESIS OF OXAHOMOPENTAPRISMANE

Ken-ichi Hirao,\* Yoshimi Kajikawa, and O. Yonemitsu

Faculty of Pharmaceutical Sciences, Hokkaido University, Sapporo, 060, Japan

Eiji Ōsawa

Department of Chemistry, Faculty of Sciences, Hokkaido University, Sapporo, 060, Japan

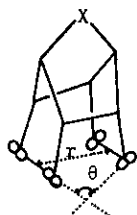
**Abstract** - Attempts were made to explain the unique inertness of oxahomohypostrophene (2) to photocyclization with the aid of molecular mechanics calculations. By using Favorskii rearrangement of bromoketone (14) as a key step, a convenient synthesis of oxahomopentaprismane (1) from cyclopentadiene or hexachlorocyclopentadiene was achieved.

We have been studying the development of the efficient methods for the construction of polycyclic structures.<sup>1</sup> This communication is concerned with a convenient synthesis of oxahomopentaprismane (1), one of the novel heterocyclic cage compounds. Though this compound has appeared in the paper by Eaton and Patterson,<sup>2</sup> neither the synthetic details nor the physical properties have been recorded. The application of photocycloaddition and Favorskii rearrangement would be promising for preparing the strained part, tricyclo[4. 2. 0. 0<sup>2,5</sup>]octane system, of 1.

The most straightforward way for the synthesis of 1 seems to be the intramolecular photocyclo-

Table. Molecular Mechanics Calculations of Oxahomohypostrophene (2) and Homohypostrophene (3)

	$r$ (Å) <sup>a</sup>	$\theta$ (deg) <sup>b</sup>	$\Delta$ Strain (kcal/mol) <sup>c</sup>
<u>2</u> (X = O)	2.77	154.3	42.08
<u>3</u> (X = CH <sub>2</sub> )	2.76	154.7	41.47



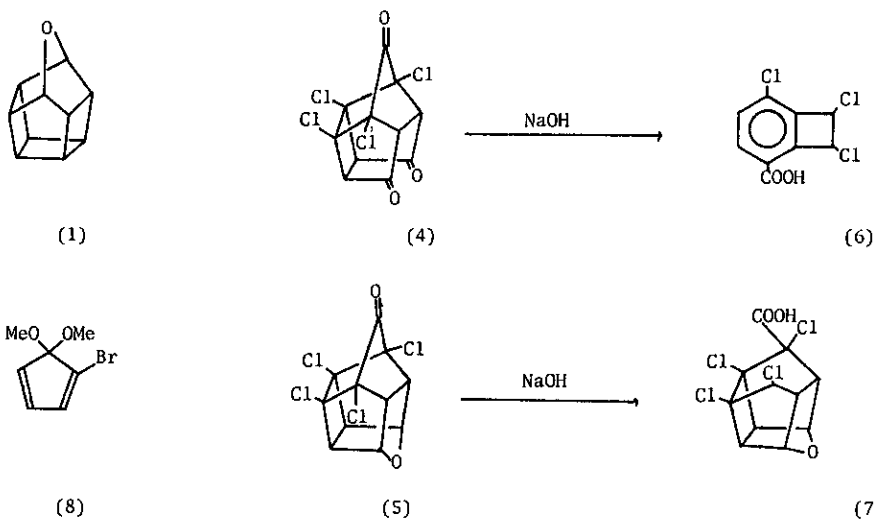
<sup>a</sup>Distance between midpoints of opposing double bonds in the minimum energy structure of starting diene.

<sup>b</sup>Dihedral angle between two  $\pi$  orbital planes of etheno bridges of starting diene.

<sup>c</sup>Difference between the calculated strain energy of cage compound and that of starting diene.

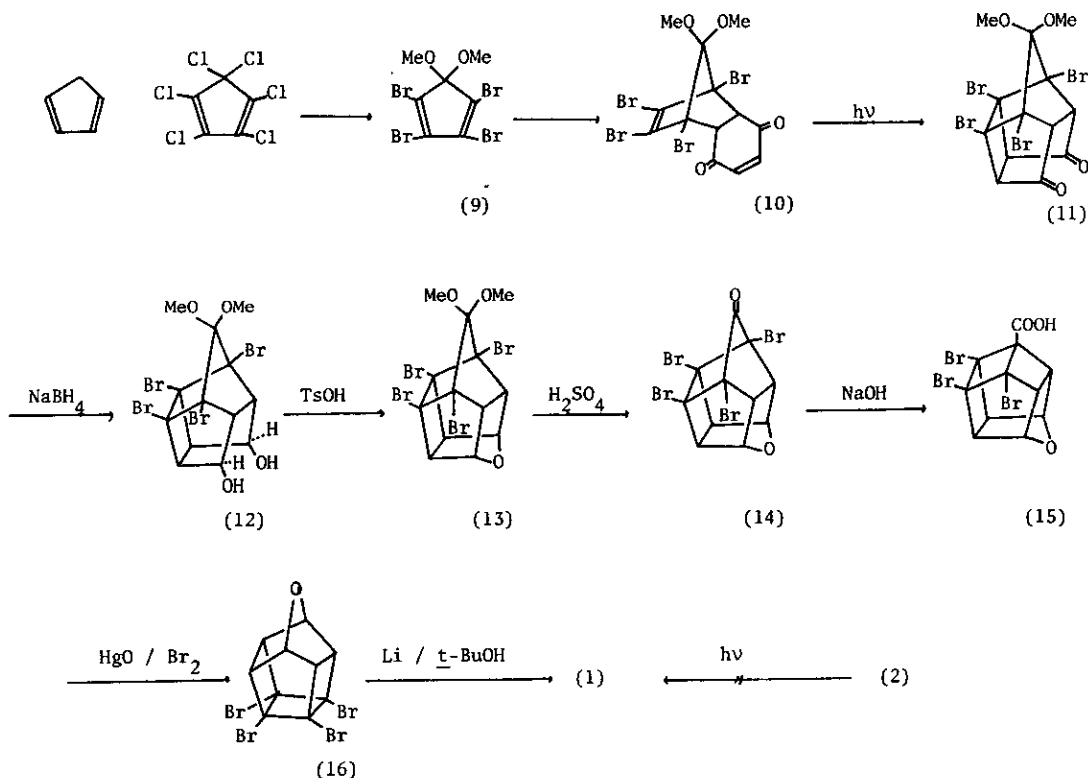
addition of oxahomohypostrophene (2), because original hydrocarbon, homohypostrophene (3), has been known to give homopentaprismane by photolysis. However, Marchand reported that in spite of repeated attempts, the direct photochemical conversion of 2 to 1 with various sensitizers was failed.<sup>4</sup> In order to learn the origin of the discrepancy between the reactivities of 2 and 3, we estimated the steric features of these compounds by molecular mechanics calculations based on the Force Fields MM 2,<sup>5</sup> and the results are summarized in Table. Though all of the three steric factors  $r$ ,  $\theta$  and  $\Delta\text{Strain}$  obtained here seem to be slightly favorable for the reaction of homohypostrophene (3), these differences are practically negligible. Therefore, other factors must be brought forward to explain the failure of intramolecular ring closure of oxahomohypostrophene (2).

There have been many examples of the Favorskii rearrangement of haloketone for the synthesis of strained cage compound.<sup>6</sup> Chloroketone, however, does not always give the expected product, because of the strong inductive effect and the weak leaving power of chlorine atom. Attempts for the synthesis of 1 through the Favorskii rearrangement of 4 and 5 were unsuccessful, giving the ring cleaved 6 and 7, respectively.<sup>7</sup> Thus, we changed the material to a bromoketone and succeeded in the synthesis of oxahomopentaprismane (1).



We had not obtained bromocyclopentadiene dimethylketal (8), which might be a suitable material for the synthesis, by using the conditions recommended by Eaton and Hudson.<sup>8</sup> Thus, tetrabromocyclopentadiene dimethylketal (9), which was obtained from cyclopentadiene or hexachlorocyclopentadiene, was converted to the diketone (11) by the known method<sup>9,10</sup> and then reduced with  $\text{NaBH}_4$  in EtOH to give the diol (12) [ 88 %, mp 290 - 293°C;  $\nu(\text{Nujol})$  3350  $\text{cm}^{-1}$ ;  $\delta(\text{CDCl}_3)$  3.18(4H, m), 3.66(3H, s), 3.72(3H, s), 4.69(1H, m), 5.39(1H, m);  $m/z$  558, 556, 554, 552, 550( $\text{M}^+$ ), 477, 475, 473, 471, 396, 394, 392, 234,

232, 155(Base)]. The stereochemistry of 12 can be confirmed on the basis of its nmr spectrum in which two different signals of protons adjacent to hydroxyl groups are seen at 4.69 and 5.39 ppm.<sup>11</sup> The ether (13) [ 94 %; mp 256 - 258°C;  $\nu$ (Nujol) 1210, 1030  $\text{cm}^{-1}$ ;  $\delta$ ( $\text{CDCl}_3$ ) 3.27(4H, broad s), 3.65(3H, s), 3.70(3H, s), 5.28(2H, m); m/z 540, 538, 536, 534, 532( $\text{M}^+$ , Base)], prepared by the dehydration (TsOH, toluene, reflux, 3h) of 12 was converted into the bromoketone (14) [ 66 %; mp 232 - 235°C(decomp);  $\nu$ (Nujol) 1800  $\text{cm}^{-1}$ ;  $\delta$ ( $\text{CDCl}_3$ ) 3.32(2H, m), 3.54(2H, m), 5.70(2H, m); m/z 459, 457, 455, 453( $\text{M}^+$  - Br, Base)] by the acidic conditions ( $\text{c-H}_2\text{SO}_4$ , room temp, 24 h). Refluxing the toluene solution of 14 with powdered NaOH for 30 min gave the desired carboxylic acid (15) [ 68 %; mp 145 - 146°C;  $\nu$ (Nujol) 3400, 1710  $\text{cm}^{-1}$ ;  $\delta$ (DMSO -  $d_6$ ) 3.63(4H, m), 5.52(2H, m)]. The Hunsdiecker reaction of 15 with  $\text{HgO} - \text{Br}_2$ <sup>12</sup> resulted in formation of tetrabromide (16) [ 65 %; mp 265 - 268°C (decomp);  $\nu$ (Nujol) 1215, 1090, 1000  $\text{cm}^{-1}$ ;  $\delta$ ( $\text{CDCl}_3$ ) 3.59(4H, t,  $\underline{J}$  3 Hz), 5.42(2H, quintet,  $\underline{J}$  3 Hz); m/z 357, 355, 353, 351 ( $\text{M}^+$  - Br - CO), 276, 274, 272(351 - Br, Base)]. Finally, 16 was subjected to the reductive debromination with  $\text{Li} / \underline{t}$ -BuOH in THF to give 1 [ 56 %; mp 169 - 170°C (lit,<sup>2</sup> 171 - 172°C):  $\nu$ (Nujol) 1300, 1240, 1010, 940, 900  $\text{cm}^{-1}$ ;  $\delta$ ( $\text{CDCl}_3$ ) 3.20(8H, broad s), 5.20(2H, m); m/z 146( $\text{M}^+$ ), 145, 117(Base)].<sup>13</sup>



REFERENCES

- 1 K. Hirao and O. Yonemitsu, J. Chem. Soc. Chem. Commun., 1980, 423, and references cited therein.
- 2 P. E. Eaton and D. R. Patterson, J. Am. Chem. Soc., 1978, 100, 2573.
- 3 P. E. Eaton, L. Cassar, R. A. Hudson, and D. Hwang, J. Org. Chem., 1976, 41, 1445.
- 4 A. P. Marchand, T. Chou, J. D. Ekstrand, and D. Helm, J. Org. Chem., 1976, 41, 1438.
- 5 N. L. Allinger, J. Am. Chem. Soc., 1977, 99, 8127; N. L. Allinger and Y. H. Yuh, QCPE, 1980, 12, 395.
- 6 P. E. Eaton and T. W. Cole, J. Am. Chem. Soc., 1964, 86, 3157.
- 7 A. P. Marchand and T. Chou, J. Chem. Soc. Perkin Trans. 1, 1973, 1948; Idem, Tetrahedron, 1975, 31, 2655.
- 8 P. E. Eaton and R. A. Hudson, J. Am. Chem. Soc., 1965, 87, 2769.
- 9 F. Straus, L. Kollek, and W. Heyn, Chem. Ber., 1930, 63B, 1868; R. West and P. T. Kwitowski, J. Am. Chem. Soc., 1968, 90, 4697; G. A. Ungefug and C. W. Roberts, J. Org. Chem., 1973, 38, 153.
- 10 J. Kovac and C. S. Marvel, J. Polym. Sci., 1967, 5, 1279; P. G. Pews, C. W. Roberts, and C. R. Hand, Tetrahedron, 1970, 26, 1711.
- 11 Cf. C. R. Cookson, E. Grundwell, R. R. Hill, and J. Hudec, J. Chem. Soc., 1964, 3062; T. Sasaki, E. Eguchi, T. Kiriyama, and O. Hiroaki, Tetrahedron, 1974, 30, 2707.
- 12 S. J. Cristol and W. C. Firth, J. Org. Chem., 1961, 26, 280.
- 13 Quite recently pentaprismane was synthesized. P. E. Eaton, S. U. Or, and S. J. Branca, J. Am. Chem. Soc., 1981, 103, 2134.

Received, 16th July, 1981