Tetrahedron Letters No. 31, pp. 2703-2706, 1970. Pergamon Press. Printed in Great Britain.

# THE ADDITION OF DICHLOROCARBENE TO 3-METHOXYCYCLOHEXENE

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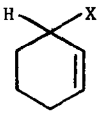
(Received in USA 1 June 1970; received in UK for publication 8 June 1970)

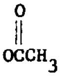
Hetero atom containing substituents on the 3-position of cyclohexene can, in selected cases, influence the addition of electrophilic species to the double bond in a highly stereoselective cis fashion. Thus, epoxidation[1] of 1 and 2 and Simmons-Smith reaction of 1,[2,3] 3,[3] 4,[4] and 5[5] affords the cis product, while the addition of mercuric acetate to 1, 3, and 4 yields mainly the trans-3-hydroxy product, after demercuration.[6]

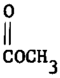


1, X = OH

2, X = 
$\mathrm{NH\overset{\overset{O}{\|}}{C}\phi}$

3, X = $OCH_3$

4, X = 
$\mathrm{O\overset{\overset{O}{\|}}{C}CH_3}$

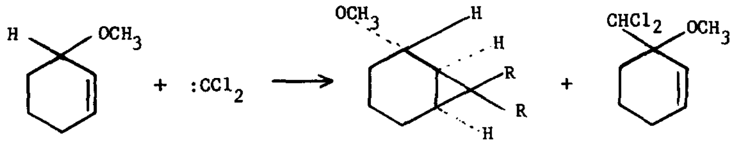
5, X = 
$\mathrm{\overset{\overset{O}{\|}}{C}OCH_3}$

It has been suggested that the high degree of stereospecificity of these reactions is due to formation of a complex between the attacking electrophile and the 3-substituent prior to addition.[1-7,8] Thus, in each of these examples the attacking electrophile has apparently added to the double bond on the same side of the six-membered ring as the 3-substituent. In the Simmons-Smith reaction, the methylene carbene probably complexes with the 3-substituent through the associated zinc atom. This interaction results in rate accelerations[2] as well as stereoselective addition.

In contrast to this reaction, additions of dichlorocarbene to olefins appear to occur through free carbenes.[9] Whether a suitable substituent in the 3-position of cyclohexene can have a substantial directive or rate effect on the addition of free dichlorocarbene has not been reported.[10, 11]

We have examined the reaction of dichlorocarbene with 3 and found no evidence for stereoselective *cis* addition. On the contrary, our results have shown this reaction to proceed in a highly stereoselective *trans* manner, and that the presence of the methoxy group has caused a 5-6 fold decrease in the relative rate of reaction of 3 compared to cyclohexene.

When 3-methoxycyclohexene(3) was allowed to react with dichlorocarbene,[12] two product peaks were discernable by analytical glc analysis. Separation and isolation by preparative glc of the two materials gave first an addition product 6 whose nmr ($CCl_4$) displayed absorption at $\delta$ 0.92-2.00 (m, 8), 3.28 (s, 1), and 3.33 (s, 3), and second, a minor peak which proved to be a mixture containing 80% insertion product 8, whose nmr ($CCl_4$) displayed absorptions at $\delta$ 1.0-2.33 (m, 6), 3.30 (s, 3), 5.67 (m, 2) and 6.18 (m, 1) and 20% of an unidentified component.



3

6, R = Cl

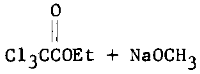
7, R = H

8

The gross structure of 6 was readily determined from its spectral properties and elemental analysis. The *trans* stereochemical relationship of the methoxyl group and cyclopropane ring in 6 was determined by reducing it, with sodium in liquid ammonia,[13] to *trans*-2-bicyclo[4.1.0]-heptyl methyl ether (7). This chlorine free material 7 was shown by nmr to contain no more than 5% of the isomeric *cis*-2-bicyclo[4.1.0]heptyl methyl ether (9).[14]

The minor product 8 from the reaction of 3 with dichlorocarbene was assigned its structure based on its nmr and infrared spectra (6.11, 9.01, 9.22, 9.36, 12.95 μ) and by analogy with reported insertion reactions.[15,16] The amount of 8 produced with respect to the major product 6 varied somewhat with the method of carbene generation selected (Table I).

TABLE I

| Method | Carbene Precursor | Reaction Temp., °C | Overall Yield, % | Product Ratio, **6**:**8**[c] |
|---|---|---|---|---|
| 1 | $CHCl_3$ + HO-*t*-Bu + $H_2O$ + NaOH | 80 to 85 | 20[a] | 4.2:1 |
| 2 |  $Cl_3CC(=O)OEt$ + $NaOCH_3$ | 0 to 5 | 28[b] | 7.1:1 |
| 3 | $CHCl_3$ + KO-*t*- Bu | -5 to 0 | 5[a] | 7.2:1 |

[a] Based on chloroform.

[b] Based on ethyl trichloroacetate.

[c] Determined before distillation of crude product mixture.

When the competitive reaction of **3** and cyclohexene for dichlorocarbene (method 2) was carried out, the latter was shown to react 5.6 times more rapidly than the former. This result suggests that no significant rate enhancing complex formation occurred between dichlorocarbene and the methoxyl oxygen of **3**. In addition, one must also conclude from the highly stereoselective *trans* addition of dichlorocarbene to 3 that the presence of the methoxyl oxygen in the 3-position of this molecule exerted no guiding or directing influence on dichlorocarbene addition to the double bond, but served only to reduce its accessibility by establishing a steric or dipole-dipole interaction between the approaching carbene and the methoxyl group or its non-bonded electron pairs.

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