Synthetic Communications: An International Journal for Rapid Communication of Synthetic Organic Chemistry

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/lsyc20

Site and Stereoselectivity of the Cyclopropanation of Unsymmetrically Substituted 1,3-Dienes by the Simmonssmith Reaction.

Mário César Guerreiro [a] & Ulf Schuchardt [a]

[a] Instituto de Química, Universidade Estadual de Campinas , Cx. P. 6154, 13083-970, Campinas, SP, Brazil

To cite this article: Mário César Guerreiro & Ulf Schuchardt (1996) Site and Stereoselectivity of the Cyclopropanation of Unsymmetrically Substituted 1,3-Dienes by the Simmonssmith Reaction. , Synthetic Communications: An International Journal for Rapid Communication of Synthetic Organic Chemistry, 26:9, 1793-1800, DOI: 10.1080/00397919608002620

To link to this article: http://dx.doi.org/10.1080/00397919608002620

SYNTHETIC COMMUNICATIONS, 26(9), 1793–1800 (1996)

SITE AND STEREOSELECTIVITY OF THE CYCLOPROPANATION OF UNSYMMETRICALLY SUBSTITUTED 1,3-DIENES BY THE SIMMONS-SMITH REACTION.[+]

Mário César Guerreiro and Ulf Schuchardt[*]

Instituto de Química, Universidade Estadual de Campinas, Cx. P. 6154.
13083-970 - Campinas, SP, Brazil.

Abstract: In the Simmons-Smith reaction, 1,3-dienes are preferentially cyclopropanated at the more electron-rich double bond to afford the *trans*-vinylcyclopropane; an allylic hydroxyl group increases the reactivity and directs the cyclopropanation to the adjacent double bond.

The cyclopropanation of olefins, first described by Simmons and Smith,[1] is a useful and well studied reaction. Several years ago we reported that the copper salt, used as an activator for the zinc in the Simmons-Smith reaction, acts as a catalyst for carbene transfer from the organozinc compound to the olefin.[2] Not much is known, however, about the cyclopropanation of 1,3-dienes by the Simmons-Smith reaction.[3-7] Even less is known about the siteselectivity of the cyclopropanation of

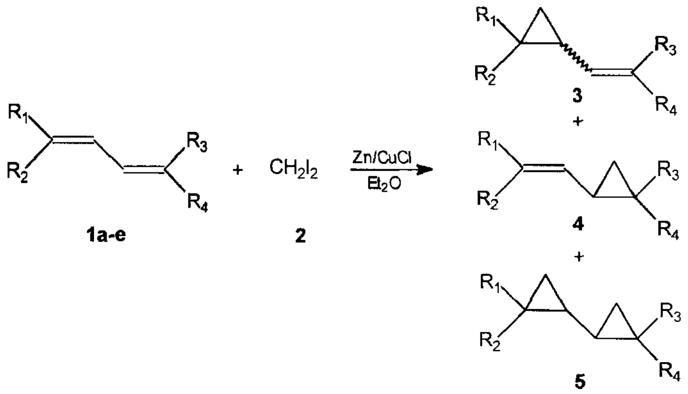
---

[*] To whom correspondence should be addressed.

[+] Part of the results was presented at the XVIth International Conference on Organometallic Chemistry, Brighton, July 1994, abstract P228.

unsymmetrically substituted 1,3-dienes.[8-12] We wish to report here our results on the cyclopropanation of symmetrically and unsymmetrically substituted 1,3-dienes.

Results: The dienes **1a**-**d** are much less reactive than substituted monoenes[2] needing higher temperatures and longer reaction times to be cyclopropanated. Also, the reaction mixtures were pressurized, and the yield of **3b** improves from 9% to 11% (±0.5) when the pressure is increased from 1 to 150 bar.[13] Even so, the yields of cyclopropanation products are low (Table 1).



Vinylcyclopropane **3a** is obtained in only 12% from **1a**. The diene **1b** is more reactive but readily suffers dicyclopropanation giving tetramethyldicyclopropane **5b** in 9% yield. The carboxymethyl dienes **1c**-**d** give similar high conversions but the cyclopropanation yields are even lower. *Trans* **3d** is only formed with 4% yield. *Trans*-**3c**, *cis*-**3c** and *trans*-

Table 1

Yields of products obtained in the on of **1a-e** with **2** at 150 bar, 80°C, for 96 h.

1	R^1	R^2	R^3	R^4	Conv. of **1** (%) [a]	Yield (%)			
						trans-**3**	*cis*-**3**	*trans*-**4**	**5**
a	H	H	H	H	68	12			2
b	CH_3	CH 3	CH_3	CH_3	70	11			9
c	CH_3	H	H	CO_2Me	70	5	1	1	--
d	CO_2Me	H	H	CO_2Me	80	4	--	--	--
e	CH_3	H	H	CH_2OH	89 [b]	--	--	18	--

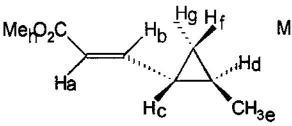
a) Conv. of **1** (%): percentage of **1** consumed during the reaction (conversion).

b) reaction performed under reflux in Et_2O for 17 h.

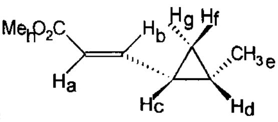
Table 2

Chemical shifts for the **3c** isomers and **4c**

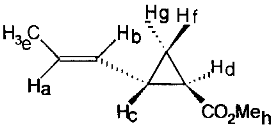
Comp.\H	H_a	H_b	H_c	H_d	H_e	H_f	H_g	H_h
trans-**3c**	5,75(d)	6,40(dd)	1,20(m)	0,95(m)	1,05(m)	0,75(m)	0,65(ddd)	3,65(s)
cis-**3c**	5,85(d)	6,65(dd)	1,55(m)	1,20(m)	1,05(m)	1,05(m)	0,40(ddd)	3,65(s)
4c	5,50(m)	4,95(m)	1,30(m)	1,80(m)	1,55(dd)	1,70(m)	0,70(m)	3,65(s)



trans-**3c**



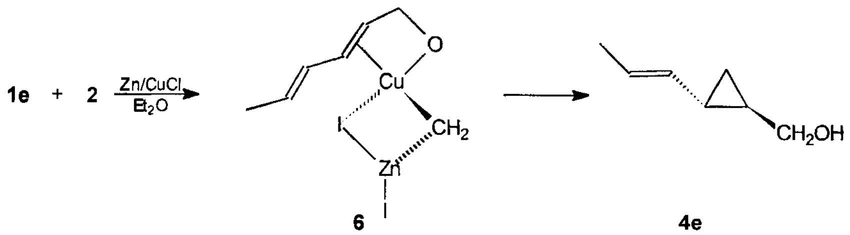
cis-**3c**



4c

4c are obtained with an overall yield of 7%. The different isomers were identified by homonuclear correlation spectroscopy (^1H-^1H). The attribution of the proton signals is shown in Table 2. The preferential formation of *trans*-**3c** shows that the *E* configuration of **1c** is mostly maintained and that the more electron-rich double bond is more easily cyclopropanated.

Diene **1e** is much more reactive than **1a**-**d**. When reacted with **2** under the same conditions used before, the products are totally carbonized. We, therefore, used the same conditions found convenient for the cyclopropanation of allylic alcohol.[2] Under these mild conditions 89% of **1e** is converted giving one single product. This product was isolated by fractionated distillation and identified by ^1H NMR spectroscopy to be *trans*-**4e**. As this compound was slightly contaminated with **1e**, the identification was confirmed by homonuclear correlation spectroscopy (^1H-^1H). Coupling of the olefinic protons with the methyl group in *trans*-**4e** clearly shows that the other double bond has been cyclopropanated. In a NOE experiment the $HOCH_2$- protons were irradiated. No significative increase of the olefinic protons confirms the *trans* configuration of **4e**. In order to explain the good reactivity of **1e** compared to **1a**-**d** and the high site- and stereoselectivity of the cyclopropanation, we propose an intermediate complex **6** in which the methylene and **1e** are coordinated to copper(I).



6 **4e**

Experimental: Butadiene **1a** (Petroquímica União, 99.5%), 2,5-dimethyl-2,4-hexadiene **1b** (Aldrich, >95%), methyl *E,E*-2,4-hexadienoate **1c** (Ega

Chemie, 99.5%), dimethyl *E,E*-muconate **1d** (Aldrich, 98 %) *E,E*-2,4-hexadien-1-ol **1e** (Aldrich, > 98%), diiodomethane **2** (Aldrich, >99%), Zinc dust (H-Herzog, >99%), cuprous chloride (Merck, >99%) were used as purchased. Diethyl ether (Et_2O) was dried with sodium-potassium alloy and distilled immediately before use.

The reactions were performed in a 90 mL glass-lined stainless steel autoclave with magnetic stirring. The autoclave was charged with 6.37g (0.0975 mol) of zinc dust and 0.95g (0.0096 mol) of cuprous chloride, closed and evacuated at 40°C for 3 h in order to dry the reagents. It was then purged with argon, opened to add 25 mL of dry Et_2O, closed and heated to 40°C for another 30 min. After opening 0.0196 mol of **1a-d** and 6.98g (0.0261 mol) of **2** were added. It was then pressurized with argon to 150 bar and reacted under magnetic stirring at 80°C for 96 h.

Cyclooctadiene (0.5 g, weighed with precision of 0.0001 g) was added as internal standard to the reaction mixture, which was then centrifuged at 2,500 rpm for 20 min. The liquid phase was removed and the solids washed with two portions of Et_2O (10 mL each) using centrifugation. The combined liquid phases were washed with three portion of a saturated solution of ammonium chloride (20 mL each) and three portions of distilled water (20 mL each). The Et_2O solution was dried with anhydrous magnesium sulphate, filtered and concentrated for gas chromatographic analysis. The reaction products were identified by

GC/MS analysis, using a HP5890 gas chromatograph equipped with a 25mx0.2mmx0.33μm HP ultra 1 column and coupled to a HP 5970B mass detector. All compounds, with exception of **4e** were quantified by gas chromatography using a Siemens Sinchromat 1 gas chromatograph equipped with a 12mx0.2mmx0.33μm HP ultra 1 column coupled to a FID. Calibrations curves were constructed for the compounds **1a**-**d** and used to quantify the products.

The reaction of **1e** was performed under reflux in Et_2O, using twice the quantities of reagents and the same preparation procedure of the couple described above. However, the diiodomethane was added dropwise to the reaction mixture during 2 h and the reaction was continued for another 15 h. After evaporation of Et_2O at normal pressure, product **4e** was isolated by distillation in a microdistillation apparatus through a 12 cm Vigreux column at reduced pressure (12 mmHg). Yield of **4e**: 0.79 g (18%), b.p. 91-92 $^{\circ}$C/12 mmHg, found: 74.8% C, 10.7% H (Calc: 75.0% C, 10.7 H), MS: m/Z 112(15%), 94(13%), 81(100%), 79(89%), 68(75%), 67(90%), 53(65%), ^{1}H NMR (300 MHz, $CDCl_3$): δ 5.50 (ddq, J = 15.22, 6.50, 0.67 Hz, 1 H, CH3CH=), 5.03 (ddq, J = 15.22, 8.29, 1.59 Hz, 1H, -CH-C**H**=), 1.25 (ddm, J = 8.29, 0.67 Hz, 1 H, C=CH-C**H**-), 1.07 (b d, J = 8.20 Hz, 1 H, $HOCH_2$C**H**-), 1.62 (dd, J = 6.50, 1.59 Hz, 3 H, C=CH-C**H**$_3$), 0.54-0.62 (m, 2 H, -CH-C**H**$_2$-CH) 3.50 (d, J = 8.20 Hz, 2 H, HOC**H**$_2$-) 1.85 (s, 1 H, -CH_2O**H**).

Acknowledgments: Financial support from FAPESP and CNPq is acknowledged.

References:

1 Simmons, H. E., Cairns, T. L., Vladuchick, S. A. and Hoiness, C. M. in “Organic Reactions”, v 20, W. G. Dauben (ed.), John Wiley & Sons, New York, 1973, pp.1-131.

2 Schuchardt, U., Nery, J. H. S. and Zuiani, M. A., *J. Braz. Chem. Soc.*, 1991, **2**,61. C. A. **118**:191206j.

3 Jorgenson, M. J. and Leung, T., *J. Am. Chem. Soc.*, 1968 ,**90**, 3769.

4 Büchel, K. H. and Korte, F., *Z. Naturforsch*, 1962, **B**, **17**, 349.

5 Overberger, C. G. and Halek, G. W., *J. Org. Chem.*, 1963, **28**,867.

6 Grzybowska, B., Konox , J. H. and Trotman-Dickensons, A. F., *J. Chem. Soc.*, 1961, 4402.

7 Doyle, M. P., in “Catalysis of Organic Reactions”, R. L. Augustine (ed.), Marcel Dekker, Inc., New York, 1986, p. 47.

8 Laurent, H., Müller, H. and Wiechert, R., *Chem. Ber.*, 1966, **99**, 3836.

9 Bertrand, M. and Maurin, R., Bull. Soc. Chim. Fr., 1967, 3549

10 Corey, E. J., Yamamoto, H., Herron, D. K. and Achiwa, K., *J. Am. Chem. Soc.*, 1970, **92**, 6635.

11 Harrison, I. T., Rawson, P. J., Turnbull, R. and Fried, J. H., *J. Org. Chem.*, 1971, **36**,3515.

12 Schwarz, S. and Siemamn, H. J., Ger. Offen, DE 4,239,945, 1994

13 Guerreiro, M. C., MSc. Thesis, Universidade Estadual de Campinas, Campinas, 1993.

(Received in the USA 24 October 1995)