Tetrahedron Letters No. 21, pp 1863 - 1864.
©Pergamon Press Ltd. 1979. Printed in Great Britain.
0040-4039/79/0515-1863$02.00/0

METAL-CATALYZED ORGANIC PHOTOREACTIONS. ONE-STEP SYNTHESIS OF (±)-FRONTALIN BY THE TITANIUM(IV) CHLORIDE-CATALYZED PHOTOREACTION OF HEPTANE-2,6-DIONE

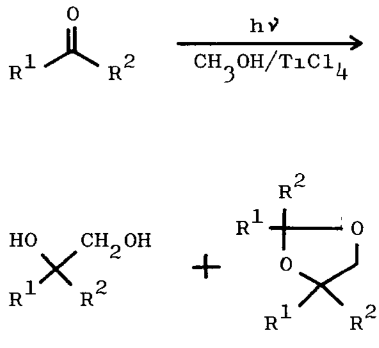
Tadashi SATO*, Shin-ichi YAMAGUCHI, and Hirokazu KANEKO
Department of Applied Chemistry, Waseda University, Ookubo 3,
Shinjuku-ku, Tokyo 160, Japan

Frontalin was synthesized from heptane-2,6-dione by the titanium(IV) chloride-catalyzed photoreaction.

Frontalin, a pheromone of southern pine beetle, <u>D. frontalis</u>, was first isolated by Kinzer, et al. in 1969, and the structure was determined as 1,5-dimethyl-6,8-dioxabicyclo[3,2,1]octane 4, by the synthesis of the racemate.[1] The absolute configuration was assigned as (S)-(-)-form by the stereoselective synthesis of the active forms by Mori,[2] Ohrui,[3] Fraser-Reid,[4] and Magnus.[5] The synthesis of the racemate has been accomplished by Kinzer,[1] Mundy,[6] D'Silva,[7] and Mori.[8]

In the course of our studies on the metal-catalyzed photoreactions,[9] we have observed a unique catalytic behavior of titanium(IV) chloride in the photoreaction of α,β-enones in methanol.[10] As an extension of the reaction,

Table 1.



1 2

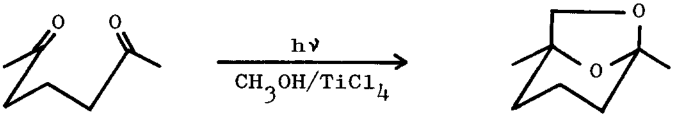
Starting ketones		Yields (%) of products	
R^1	R^2	1	2
CH_3	C_2H_5	54	
C_2H_5	C_2H_5	55	
CH_3	$n\text{-}C_3H_7$	68	
CH_3	$(CH_2)_2COOH$	56[a]	
$-(CH_2)_4-$		35	
$-(CH_2)_5-$		76	21
$-(CH_2)_6-$		35	
$-\underset{\substack{\vert\\ CH_3}}{C}H(CH_2)_4-$		42[b]	26
$-(CH_2)_2\underset{\substack{\vert\\ t\text{-}Bu}}{C}H(CH_2)_2-$		48[c]	19

a. Isolable as γ-lactone.

b. A mixture of Z- and E-forms. (76 : 24)

c. A mixture of Z- and E-forms. (69 : 31) we recently found that the saturated ketones give 1,2-diols 1, accompanied in some cases by ketals 2 as minor products, when irradiated in methanol with quartz-filtered light in the presence of titanium(IV) chloride.[11] The results are summarized in the Table 1. In the absence of titanium(IV) chloride, the reaction usually afforded a mixture of several products in small amounts. This reaction was now applied for the synthesis of (±)-frontalin.

A solution of heptane-2,6-dione 3 (1.755 g) and titanium(IV) chloride (0.75 ml) in methanol (150 ml) was irradiated in quartz vessel with high-pressure mercury lamp (Ushio UM 452, 450 W) for 3 h. The clear blue solution was diluted with water, and extracted with dichloromethane. Evaporation of the solvent left almost pure frontalin 4 as a colorless oil. Distillation gave pure sample, 1.136 g (58.3%). Bp 90°/94 mmHg. The product indicated the spectroscopic data (NMR, IR, and MS) identical with those of (S)-(-)-frontalin.[3] Since heptane-2,6-dione can be prepared easily from diketene and formalin,[12] the present reaction could be a facile method of the frontalin synthesis.



3 4

The authors are indebted to Dr. H. Ohrui, The Institute of Physical and Chemical Research, for presenting us the spectroscopic data of frontalin.

References

1. G. W. Kinzer, A. F. Fentiman, Jr., T. F. Page, Jr., and R. L. Foltz, Nature, 221, 477 (1969).
2. K. Mori, Tetrahedron, 31, 1381 (1975).
3. H. Ohrui and S. Emoto, Agr. Biol. Chem., 40, 2267 (1976).
4. D. R. Hicks and B. Fraser-Reid, J. C. S. Chem. Comm., 1976, 869.
5. P. Magnus and G. Roy, J. C. S. Chem. Comm., 1978, 297.
6. B. P. Mundy, R. D. Otzenberger, and A. R. DeBernardis, J. Org. Chem., 36, 2390 (1971).
7. T. D. J. D'Silva and D. W. Peck, J. Org. Chem., 37, 1828 (1972).
8. K. Mori, S. Kobayashi, and M. Matsui, Agr. Biol. Chem., 39, 1889 (1975).
9. E. Murayama and T. Sato, Bull. Chem. Soc. Jpn, 51, 3022 (1978).
10. T. Sato, S. Yoshiie, T. Imamura, K. Hasegawa, M. Miyahara, S. Yamamura, and O. Ito, Bull. Chem. Soc. Jpn, 50, 2714 (1977).
11. H. Kaneko, S. Yamaguchi, and T. Sato, Abstr. No. 2M30, 37th National Meeting of the Chemical Society of Japan, Yokohama, April 1978.
12. R. A. Micheli, Z. G. Hajos, N. Cohen, D. R. Parrish, L. A. Portland, W. Sciamanna, M. A. Scott, and P. A. Wehri, J. Org. Chem., 40, 675 (1975).

(Received in Japan 13 February 1979)