Communications to the Editor

[Chem. Pharm. Bull.
33(8)3552—3554(1985)]

INTRAMOLECULAR PHOTOCYCLOADDITION OF THIOSUCCINIMIDES WITH ALKENYL N-SIDE CHAINS: SYNTHESIS OF STRAINED MULTICYCLIC SPIRO-THIETANES[1)]

Minoru Machida,*,[a] Kazuaki Oda,[a] and Yuichi Kanaoka[b]
Faculty of Pharmaceutical Sciences, Higashi-Nippon-Gakuen University,[a]
Ishikari-Tobetsu, Hokkaido 061-02, Japan and Faculty of
Pharmaceutical Sciences, Hokkaido University,[b]
Sapporo 060, Japan

Irradiation of thiosuccinimides 3a-d gave, efficiently, highly strained thietanes 4a-c, and thietane 4d with a pyrrolizidine skeleton

KEYWORDS —— thioimide; intramolecular photocycloaddition; spiro-thietane; pyrrolizidine; photoreaction; strained thietane

As part of our continuing program to investigate imide photochemistry,[2)] we have explored photoreactions of thioimide systems, a new amalgamation of imide and sulfur.[3)] It was found that various aliphatic and aromatic cyclic thioimides (1) undergo efficient [2 + 2] photocycloadditions intermolecularly with olefins to give various thietanes (2) (Chart 1).[3)] Interestingly, certain thioimides were inert to the Norrish type I and II reactions[3,4)] in contrast to the behavior of their oxygen analogs (imides).[2)] In order to see the generality of the photocycloaddition reactions in the thioimide systems, the intramolecular photoreaction of thiosuccinimides was studied. Thus, we wish to report the first example of intramolecular thietane formation in the thiosuccinimides possessing an alkenyl group in their N-side chains.

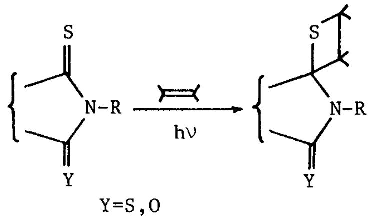
Irradiation of 3a,b (5 mmol) in benzene (500 ml) with a 1 kW high-pressure mercury lamp under a nitrogen atmosphere gave, after chromatographic separation, highly strained tricyclic thietanes 4a,b, whose structures were assigned on the basis of spectral and analytical data.[6)]

To gain more information about the role of the sulfur atom in the thioimide system with respect to the corresponding imide system,[7)] the photoreaction of 3c was examined. The monothiosuccinimide 3c predominantly underwent intramolecular photocycloaddition at the thiocarbonyl to afford thietane 4[6)] rather than oxetane. This preference of the thietane formation is interesting in comparison with the photochemical behavior of monothiosuccinimide with olefins, involving the intermolecular formation of both thietane and oxetane (ratio, 3:1).[3,9)]

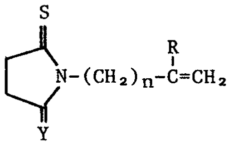
Further, irradiation of 3d gave efficiently the expected thietane 4d,[6)] having a pyrrolizidine skeleton. By contrast, with the oxygen analogs (succinimides), such a photocycloaddition involving the formation of a five membered ring system was not observed. Instead, typical γ-hydrogen abstraction occurred.[10)]

This preferential cycloaddition in the thioimide systems provides a facile synthetic method for highly strained thietanes. These compounds are not only interesting spiro multicycles as models of highly strained ring systems for theoretical studies, but also serve as otherwise inaccessible intermediates susceptible to various transformations. Further, these reactions afford an attractive route to a novel synthesis of pyrrolizidine ring systems such as naturally occurring pyrrolizidine alkaloids.[11)]

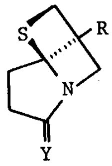
Chart 1



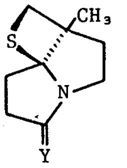
1 2



3a-d



4a-c



4d

3	Time (h)	Yield (%) of 4
a: Y=S, n=1, R=H	1	31 (Oil)
b: Y=S, n=1, R=CH_3	1	82 (Oil)
c: Y=O, n=1, R=CH_3	6	42 (Oil)
d: Y=S, n=2, R=CH_3	0.25	65 (Oil)

ACKNOWLEDGEMENT This work was supported in part by a grant from the Ministry of Education, Science and Culture (To Y. K., No. 58110005).

REFERENCES AND NOTES

1) a) Photochemistry of the Nitrogen-Thiocarbonyl Systems, Part 4. Part 3: M. Machida, K. Oda, E. Yoshida, S. Wakao, K. Ohno, and Y. Kanaoka, Heterocycles, 23, 1615 (1985); b) Photoinduced Reactions. Part 77. Part 76: see ref. 1a.

2) a) Y. Kanaoka, Acc. Chem. Res., 11, 407 (1978); b) M. Machida, K. Oda, and Y. Kanaoka, Tetrahedron, in press and references cited therein.

3) M. Machida, K. Oda, E. Yoshida, and Y. Kanaoka, J. Org. Chem., 50, 1681 (1985).

4) Aoyama, Omote et al. studied photoreactions of related acyclic monothioimides such as thiobenzoylamide derivatives and reported hydrogen-abstractions[5a,b)] and cycloaddition.[5c)]

5) a) H. Aoyama, M. Sakamoto, and Y. Omote, Chem. Lett., 1983, 1397; b) M. Sakamoto, H. Aoyama, and Y. Omote, J. Org. Chem., 49, 1837 (1984); c) M. Sakamoto, Y. Omote, and H. Aoyama, ibid., 49, 396 (1984).

6) Satisfactory spectral (IR, ^{1}H- and ^{13}C-NMR, and high-MS) and elemental analytical data were obtained for all the new compounds. As a typical example, the mass spectrum of 4b showed the molecular ion peak at m/z 185 and a characteristic fragment peak (m/z 139) corresponding to the loss of S=CH_2 from the molecular ion,[1a)] indicating that the carbon with a methyl

group is not adjacent to the sulfur atom in the thietane ring. In the ^{1}H-NMR spectrum of 4b, two doublets with a coupling constant of 12 Hz appeared at 4.0 and 4.7 ppm, respectively, suggesting the presence of methylene protons adjacent to the nitrogen atom in the newly formed ring. Further, two peaks at 1.25 and 3.25 ppm indicated respectively the presence of a methyl and a methylene adjacent to the sulfur atom. The ^{13}H-NMR spectrum showed the presence of two quaternary carbons and one thiocarbonyl carbon at 56.1 (s), 88.8 (s, a spiro carbon), and 205.0 (s). Four other peaks appeared at 32.4 (thiolactam ring), 33.5 (thiolactam ring), 43.7 (CH_2-S), and 66.6 (N-CH_2) as a triplet, respectively, in the off-resonance decoupled spectrum. Similar spectral data also indicated that the thietane 4d is not the head to tail, but the head to head addition product.

7) It was reported that, in the prolonged irradiation of their oxygen analogs (succinimides), N-allylsuccinimide (an analog for 3a) in acetonitrile gave no detectable products. In acidified methanol, an azepinone derivative formed, probably *via* oxetane, whereas an analog of 3b gave efficiently oxetane in acetonitrile.8)

8) K. Maruyama and Y. Kubo, J. Org. Chem., 42, 3215 (1977).

9) None of the oxetane was isolated from the reaction mixture, indicating that the oxetane formation is, if any, very minor.

10) M. Machida, K. Oda, and Y. Kanaoka, Chem. Pharm. Bull., 32, 950 (1984).

11) T. H. Jones and M. S. Blum,"Alkaloids: Chemical and Biological Perspectives," Vol. 1, Ed., by S. D. Pelletier, John Wiley and Sons, Inc., New York, 1983, p. 33.

(Received May 31, 1985)