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Photolyses of 2-(Alkylthio)carbonyl-2-(arylethyl)propyl Cobaloxime¹⁾

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2-(Alkylthio)carbonyl-2-(arylethyl)propyl cobaloximes were photolyzed. When an aryl group is phenyl, a major process is a radical cyclization to give 2-(alkylthio)carbonyl-2-methyltetralin. On the other hand, β -thiolactone is a major product when an aryl group is mesityl and an alkyl group is t-butyl.

We have been concerned with the biomimetic radical rearrangement of a thioester group by using an organocobaloxime, organo(pyridine)-bis-dimethylglyoximatocobalt(III), as a coenzyme model, and have suggested the possible involvement of cobalt in the rearrangement step.^{2,3)} In the previous study, 2-(alkylthio)carbonyl-2-phenylpropyl cobaloxime <u>A</u> (X=Ph) and 2-(alkylthio)carbonyl-2-methylpropyl cobaloxime <u>A</u> (X=Me) were photolyzed to generate radicals <u>B</u> which rearrange to radicals <u>C</u>.²⁾ In the former system (<u>A</u>, X=Ph) the formation of of a benzyl radical <u>C</u> (X=Ph) may be a driving force of the thioester rearrangement. In the latter system (<u>A</u>, X=Me) highly volatile products were ignored due to the experimental difficulty.²⁾ These situations prompted us to investigate the behaviors of 2-(alkylthio)carbonyl-2-(arylethyl)propyl radicals <u>B</u> (X=PhCH₂CH₂ and MesCH₂CH₂).



The reactions of 2-(alkylthio)carbonyl-2-phenethylpropyl bromide (alkyl=Et or t-Bu)⁴⁾ and 2-(alkylthio)carbonyl-2-mesitylethyl)propyl bromide (alkyl=Et or t-Bu)⁴⁾ with 1.2 molar equivalents of tributylstannane $(10^{-3} - 10^{-1}M)$ in benzene gave only 2-(alkylthio)carbonyl-2-phenetylpropane (2) and 2-(alkylthio)carbonyl-2-phenetylpropane (2) and 2-(alkylthio)carbonyl-2-(mesitylethyl)propane (6). This feature can be explained by the preferential hydrogen transfer from tributylstannane to the radical of type <u>B</u> since the rearrangement of the thioester group is slow compared to the hydrogen transfer.

Photolyses of 2-(alkylthio)carbonyl-2-phenetylpropyl cobaloxime $(\underline{1})^{5}$ in a variety of solvents gave products $\underline{2}$, $\underline{3}$, and $\underline{4}$ as listed in Table 1.⁶⁾ A thioester rearranged product $\underline{3}$ was obtained only from the ethylthioester $\underline{1}$ (R=Et) in minute amount and main products were cyclized ones $\underline{4}$ except for the photolysis in chloroform. To retard the radical cyclization to tetralin derivatives, 2-(alkylthio)-carbonyl-2-(mesitylethyl)propyl cobaloxime $(\underline{5})^{5}$ was photolyzed in similar solvent

systems to give the products <u>6</u>, <u>7</u>, and <u>8</u>, and the results are summarized in Table 2.⁶⁾t-Butylthioester <u>5</u> (R=t-Bu) gave a β -thiolactone <u>8</u> as a major product and it is in sharp contrast to the formation of the tetralin derivative <u>4</u> from the cobaloxime 1.

Products 2 and 6 were identified with authentic samples prepared by α -methylation of the corresponding aralkylthioesters. The structures of rearranged product 3^{7} and 7^{7} were deduced from the comparison of spectral data with those of the related compounds, S-alkyl 3-methyl-3-butenethioate and S-alkyl 3-phenyl-3-butenethioate.²⁾ Product 7 (R=Et) shows NMR signals due to the endo-methylene (δ =5.02 and 5.07) and the methylene adjacent to the (alkylthio)carbonyl group (3.31, d, J=0.7). Structures $4 (R=Et)^{8}$ were deduced from an IR absorption for -COSR (1680 cm⁻¹) and NMR signals: a singlet due to the methyl at 1.23 and an AB-quartet at 2.53 and 3.25 (J=16) due to the isolated benzylic methylene. Structure $\frac{8}{2}$ was characterized by an IR absorption at 1755 cm⁻¹ due to β -thiolactone¹⁰⁾ and NMR signals: a singlet due to the methyl at 1.47, and an AB-quartet at 2.78 and 3.00 (J=8.5). The chemical shift of the quartet is typical for the methylene adjacent to sulfur in β -thiolactone ring. β -Propiothiolactone and α -dimethyl- β -propiothiolactone have signals at 3.05 and 2.73, respectively, due to the β -methylene whereas β -propiothiolactone and its β -substituted derivatives have signals due to the α -methylene at around $\delta=4$.¹⁰⁾ An alternative structure for <u>8</u>, β -disubstituted β -thiolactone, was eliminated from these spectroscopic features and the analogous formation of α -dimethyl- β -propiothiolactone, which was identified by reported spectroscopic data,¹⁰⁾ on the photolysis of 2-(t-butylthio)carbonyl-2-methylpropyl cobaloxime (A, R=t-Bu, X=Me).

In the photolysis of <u>1</u> the radical cyclization to give tetralin derivarives <u>4</u> prefers to the hydrogen abstraction to give reduction products <u>2</u>, which in turn prefers to the radical rearrangement of the thioester group. The ethylthioester <u>5</u> (R=Et) gives preferably a reduction product <u>6</u> (R=Et) but the t-butylthioester 5 (R=t-Bu) gives a reduction product <u>6</u> (R=t-Bu) as a minor product except for the photolysis in chloroform, a strongly hydrogen donating solvent. In less hydrogen donating solvents, formations of the rearranged product <u>7</u> (R=Et) from <u>5</u> (R=Et) and β -thiolactone from 5 (R=t-Bu), respectively, become more significant.

Three types of collapsing processes exist for the radical intermediate of mesityl derivatives, and both a direct hydrogen abstraction and a thioester rearrangement <u>via 10</u> are major processes for the radical intermediate <u>9</u> (R=Et) but the thiolactone formation is more significant for the radical intermediate <u>9</u> (Ar=Mes, R=t-Bu). Thus mesityl group retards the radical cyclization to benzene ring and the rearrangement of the thioester group is rather significant with the ethylthioester. Nevertheless, a thiolactonization by the loss of alkyl group becomes significant with t-butylthioester. This must be due to a facile cleavage of the t-butyl-sulfur bond to result in the radical substitution on sulfur. These results indicate the existence of the equilibrium between the radicals <u>10</u> and <u>11</u>. The formula <u>11</u> represents an intermediate of S_H² reaction on sulfur, which has a trigonal bipyramid geometry.



| Table | 1. | Photolvses | of | cobaloxime | 1 | 6) |
|-------|----|--------------|----|----------------|---|----|
| - 40 | | 1.1000011000 | 01 | 0000410.11.1.0 | _ | |

Table 2. Photolyses of cobaloxime 5^{6}

| R | solvent | $\frac{\text{Product composition}/\$}{2:3:4}$ | | | R solvent | | $\frac{\text{Product composition}/\$}{\underline{6}: \underline{7}: \underline{8}}$ | | | |
|------|---------------------------------|---|---|----|-----------|-------------------------------|---|----|----|--|
| Et | с _б н _б | 8 | 2 | 90 | Et | с ₆ н ₆ | 48 | 50 | 2 | |
| Et | СНЗОН | 13 | 3 | 84 | Et | CH ₃ CN | 66 | 30 | 4 | |
| Et | CH ₂ Cl ₂ | 28 | 2 | 70 | Et | СНЗОН | 80 | 16 | 4 | |
| Et | CHC13 | 75 | 0 | 25 | Et | CHC13 | 100 | 0 | 0 | |
| t-Bu | с ₆ н ₆ | 6 | 0 | 94 | t-Bu | C ₆ H ₆ | 4 | 4 | 92 | |
| t-Bu | СНЗОН | 19 | 0 | 81 | t-Bu | CH ₃ CN | 18 | 13 | 69 | |
| t-Bu | CH ₂ Cl ₂ | 36 | 0 | 64 | t-Bu | СНЗОН | 12 | 4 | 84 | |
| t-Bu | CHC13 | 86 | 0 | 14 | t-Bu | CHC13 | 84 | 0 | 16 | |



The thioester rearrangement has $precedent^{2,11}$ but the thiolactone formation by $S_{\rm H}^2$ reaction on sulfur has no precedent, and the present findings disclosed a novel variation of the radical substitution on sulfur atom.^{12,13}

References

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- 2) M. Tada, K. Inoue, K. Sugawara, M. Hiratsuka, and M. Okabe, Chem. Lett., 1985, 1821.
- 3) M. Tada, K. Inoue, and M. Okabe, Chem. Lett., <u>1986</u>, 703.
- 4) 2-(Alkylthio)carbonyl-2-(arylethyl)propyl bromides were prepared by the bromomethylation of S-alkyl 4-aryl-2-methylbutanothioate in THF using LDA as a base.
- 5) Cobaloximes <u>1</u> and <u>5</u> were prepared from the corresponding bromides under the standard conditions recorded in the earlier papers^{2,3)} and gave the correct elemental analyses (C, H, N) and spectral data (IR and NMR).
- 6) A solution of $\underline{1}$ or $\underline{5}$ (10 mg) in 10 ml of the solvent was irradiated by a high pressure mercury lamp (400 W) through a Pyrex filter. The reaction mixture was condensed and passed through a short column of silica gel eluted by chloroform, and separated by the preparative TLC on silica gel. Total yields of the products were 80-90% at this stage in the solvents other than benzene and 50-60% in benzene. The product composition was determined by gas chromatographic analyses using SE-30 as a stationary phase.
- 7) $\underline{7}$ (R=Et): m/z=272(M⁺); 1685 cm⁻¹(CCl₄); δ (CDCl₃) 1.24(3H, t, J=7.3), 2.23(3H, s), 2.28(6H, s), 2.87(2H, q, J=7.3), 2.70-3.20(4H, m), 3.31(2H, d, J=0.7), 5.02(1H, diff. s), 5.07(1H, diff. s), 6.82(2H, s). The mass spectra of the minor products 3 (R=Et)(M⁺=276) and 7 (R=t-Bu) (M⁺=304) showed the similar mass-fragmentation pattern to 7 (R=Et).
- 8) <u>4</u> (R=Et): m/z=232; 1680 cm⁻¹ (CCl₄); δ (CDCl₃) 1.17(3H, t, J=7), 1.23(3H, s), 1.57-2.33(2H, m), 2.53(1H, d, J=16), 2.60-3.00(2H, m), 2.80(2H, q, J=7), 3.25 (1H, d, J=16), 6.98-7.27(4H, m). <u>4</u> (R=t-Bu): 1675 cm⁻¹ (CCl₄); δ (CDCl₃)1.27(3H, s), 1.44(9H, s), 1.80-2.20(2H, m) 2.53(1H, d, J=17), 2.68-2.90(2H, m), 3.24(1H, d, J=17), 7.00-7.28(4H, m). Mass spectrum of <u>4</u> (R=t-Bu) showed the similar fragmentation pattern to <u>4</u> (R=Et) except no appearance of the molecular peak.
- 9) <u>8</u>, $m/z=248(13\%, M^{+})$, $187(6.2\%, M^{+}-COS-H)$, $173(8.4\%, M^{+}-CH_{2}SCO-H)$, $147(12\%, MesCH_{2}CH_{2}^{+})$, $133(100\%, MesCH_{2}^{+})$; $1755 cm^{-1}(CC1_{4})$; $\delta(CDC1_{3})$ 1.47(3H, s), 1.73 (2H, t, J=8.5), 2.24(3H, s), 2.27(6H, s), 2.45-2.80(2H, m), 2.78(1H, d, J=8.5), 3.00(1H, d, J=8.5), 6.82(2H, s).
- 10) P. Y. Johnson, Tetrahedron Lett., <u>1972</u>, 1991: P. Y. Johnson and G. A. Berchtold J. Org. Chem., 35, 584 (1970).
- 11) S. Wollowitz and J. Halpern, J. Am. Chem. Soc., <u>106</u>, 8313 (1984).
- 12) R. Leardini, G. F. Pedulli, A. Tundo, and G. Zanardi, J. Chem. Soc., Chem. Commun., <u>1985</u>, 1390 and references cited therein.
- 13) A. L. J. Beckwith and D. R. Boate, J.Chem. Soc., Chem. Commun., <u>1986</u>, 189 and references cited therein.

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