A FACILE REDUCTIVE DIMERIZATION OF CONJUGATED ACID DERIVATIVES WITH SAMARIUM DIIODIDE

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Summary: Conjugated esters were instantaneously hydrodimerized at room temperature by use of the reduction system, SmI₂-THF-HMPA, in the presence of proton sources. A perfect stereoselection was realized in the reaction of N,N-dibenzyl crotonamide.

In a previous paper, we reported that the SmI₂-promoted reductive coupling of aldehydes and ketones with α , β -unsaturated esters proceeded very smoothly especially when HMPA was used as co-solvent.¹ Now we found that when carbonyl compounds were not present conjugated esters readily underwent hydrodimerization under similar conditions.²⁻⁴ (Eq. 1)

$$R \underbrace{CO_2 R'}_{R'OH, rt, < 1 min} \underbrace{R \underbrace{CO_2 R'}_{R'OH, rt, < 1 min}}_{R'OH, rt, < 1 min} (1)$$

A variety of α , β -unsaturated esters instantaneously hydrodimerized at their β -position in either intermolecular or intramolecular fashion as exemplified in Table 1. The conjugated dienoic ester also dimerized at the γ -position with the migration of the remaining double bonds. The reaction of an α , β -unsaturated alkynic acid ester allowed an easy access to the 3,4-unsaturated adipic acid derivative (entry 8).

Some limitation was found in the reaction of substrates with sterically crowded environment at the β position such as methyl 3-*tert*-butylacrylate or methyl 3,3-dimethylacrylate, in which simple reduction of the
double bonds dominated over C-C bond formation. In addition, the method could not be applied to macrocyclization.⁵

Very interestingly, the reaction of N,N-dibenzyl crotonamide produced the corresponding dl-3,4-dimethyladipiamide as a single stereoisomer.⁶ (Eq. 2) Although the precise mechanism of the reaction is not clear,⁷ the stereochemistry must be controlled on the coordination sphere of samarium.



The mildness, convenience, rapidity, and in some cases, high degree of stereoselection make the present method useful though other methods utilizing metal amalgam or electrolytic process are also available.^{8,9}

Entry	Conjugated ester	Time	Product	%Yield ^{b)} (ratio) ^{C)}
1	CO ₂ Me	< 1 min		53
2	CO2C8H17	< 1 min	CO ₂ C ₈ H ₁₇ CO ₂ C ₈ H ₁₇	74 ^{d)}
3	PhCO ₂ Me	< 1 min	Ph CO ₂ Me CO ₂ Me	70 (1.9:1)
4	CO ₂ Me	< 1 min	CO ₂ Me CO ₂ Me	90 ^{d)}
5	MeO ₂ C CO ₂ Me	< 1 min	MeO ₂ C	80 (7:1)
6	CO ₂ Et CO ₂ Et	< 1 min	CO ₂ Et CO ₂ Et	87 ^{d)}
7 ^{e)}		3 min	EtO ₂ C EtO ₂ C CO ₂ Et	82 (1:1)
8	—	< 1 min	CO ₂ Me ^{f)}	48

Table 1. Sml₂-Promoted Reductive Dimerization of Conjugated Esters^{a)}

a) A Sml₂-THF solution (0.1 mol dm⁻³, 3 ml) was added to a mixture of conjugated ester (0.15 mmol), MeOH, EtOH, or t-BuOH (0.15 mmol), and HMPA (0.3 ml) in THF (0.3 ml) at room temperature under nitrogen. b) Isolated yield. c) Determined by ¹H NMR (400 MHz) analysis. d) A mixture of diastereomers, the exact ratio of which was not determined. e) N,N-Dimethylacetamide was used in place of HMPA. f) A single isomer, whose stereoconfiguration is tentatively assigned: ¹H NMR (CDCl₃) δ =1.77 (s, 6H), 3.12 (s, 4H), and 3.70 (s, 6H) ppm; ¹³C NMR δ =19.3, 39.8, 51.7, 125.6, and 172.0 ppm.

References and Notes

- 1. K.Otsubo, J. Inanaga, and M. Yamaguchi, Tetrahedron Lett., 27, 5763 (1986).
- 2. A part of this work was presented at the 56th Meeting of the Chemical Society of Japan, April, Tokyo (1988).
- 3. The addition of HMPA is crucial; in the absence of it almost no reaction or simple reduction of the double bond took place slowly.
- Yb-promoted cyclodimerization of α,β-unsaturated carbonyl compounds including methyl cinnamate has been reported recently: K. Takaki, F. Beppu, S. Tanaka, Y. Tsubaki, T. Jintoku, and Y. Fujiwara, J. Chem. Soc., Chem. Commun., 1990, 516.
- The reaction of MeO₂CCH=CH(CH₂)₈CH=CHCO₂Me under high-dilution conditions afforded the corresponding saturated diester in 95% yield.
- 6. The stereochemistry was determined by comparing the ¹H NMR (400 MHz) and ¹³C NMR(100 MHz) spectra with those of the authentic *meso*-isomer prepared from *meso*-2,3-dimethylglutaric acid in 7 steps.
- 7. The hydrodimerization is believed to proceed through the conjugated addition of the allylic radical of the ester enolate or its protonated form: See H. O. House, "*Modern Synthetic Reactions*", 2nd Ed, W. A. Benjamin, California, p. 173 (1972).
- a) M. M. Baizer and J. D. Anderson, J. Electrochem. Soc., 111, 223 (1964).
 b) For a review, see H. J. Schafer, Angew. Chem., Int. Ed. Engl., 20, 911 (1981).
 c) For a recent study on intramolecular hydrodimerization, see L. Moens, M. M. Baizer, and R. D. Little, J. Org. Chem., 51, 4497 (1986).
- 9. A part of this work was supported by Grant-in-Aid for Scientific Research (No. 02453026) from the Ministry of Education, Science and Culture, Japan.