

THE ACYLOIN CONDENSATION. III. (1) THE
SYNTHESIS OF FOUR-MEMBERED RINGS

Jordan J. Bloomfield (2)

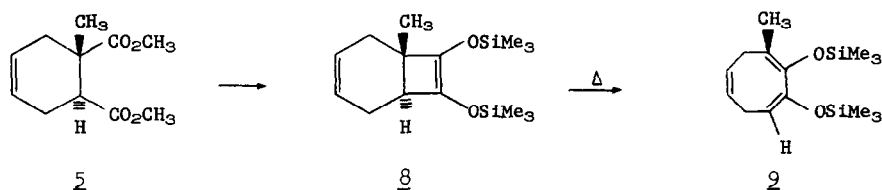
Central Research Department, Monsanto Company
Saint Louis, Missouri 63166
(Received in USA 20 September 1967)

Although the cyclic acyloin condensation has proven very useful for the formation of rings having from five to over thirty members (3), it has not been found equally satisfactory for the formation of cyclobutanes. While three examples are recorded in the literature, only in one case, the cyclization of 1,6-dicarbomethoxybicyclo-[4.4.0]-decadiene-3,8, is the yield satisfactory (1). The cyclization of 1,2-dicarbomethoxycyclohexane, 1, gave the acyloin in 13% yield while 1,2-dicarbomethoxycyclobutane gave 2-carbomethoxycyclopentanone rather than acyloin (5).

Schräpler and Rühlmann (6) have demonstrated that introduction of chlorotrimethylsilane into the reaction mixture permits isolation of the intermediate enediolates as trimethylsilyl ether derivatives. At the same time the yield of cyclic products are improved compared to the usual reaction conditions.

Application of these new conditions to the cyclization of a variety of 1,2-dicarboxylic esters has now proved strikingly successful for the synthesis of cyclobutane rings. Yields of cyclic product in the high 80% range are the rule (see Table I). These products can be easily converted to the corresponding acyloin (6).

The cyclization of trans-1-methyl-1,2-dicarbomethoxycyclohex-4-ene, 7, presents an especially interesting case. The cyclization occurs smoothly, but at the usual reaction temperature (refluxing toluene) the initial product, 8, is converted into the cyclooctatriene, 9 (t 1/2 at 100° is approximately 150 min). The bicyclooctane derivative, 8, was obtained as the sole product when the condensation was effected with a large excess of sodium-potassium alloy at room temperature.



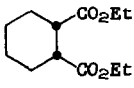
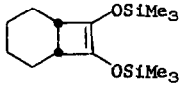
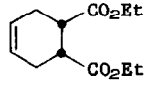
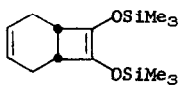
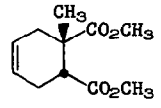
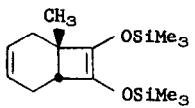
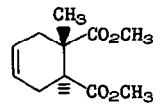
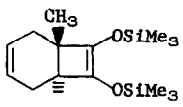
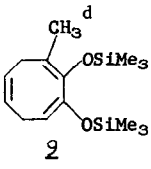
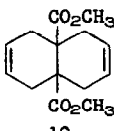
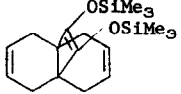
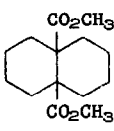
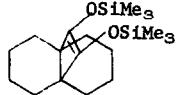
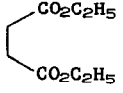
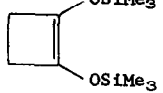
This rearrangement is a particularly interesting example of thermal conrotatory (7) cyclobutene ring opening to a cis-cis-1,3-cyclooctadiene system. The related cis-[4.2.0]-bicyclooctene systems are stable under the same conditions. Conrotatory opening in the cis-case would lead to a cis-trans-1,3-cyclooctadiene -- a system known to undergo facile thermal isomerization to the [4.2.0] system (8).

The advantages of this technique are many. 1) Higher yields of cyclic product are obtained; 2) concomitant with the higher yield is a reduction in side reactions; 3) the workup is greatly simplified -- one has only to filter the reaction mixture and distill the filtrate; 4) although all our reactions are run under oxygen free nitrogen, it is likely that ordinary nitrogen would suffice since the oxygen-sensitive enediolates have such a short lifetime; and 5) the disiloxenes are easily hydrolyzed under acid or neutral conditions (6) to the acyloin. For example, reflux with either methanol or ethanol, under nitrogen, produces the acyloins in good yield.

REFERENCES AND NOTES

1. Paper II, J. J. Bloomfield and J. R. S. Ireland, J. Org. Chem., 31, 2017 (1966).
2. Visiting Professor, Monsanto Company, 1966-1967.
3. See the review by K. T. Finley, Chem. Rev., 64, 573 (1964).
4. A. C. Cope and E. C. Herrick, J. Am. Chem. Soc., 72, 983 (1950).
5. J. J. Bloomfield, R. G. Todd and I. T. Takahashi, J. Org. Chem., 28, 1474 (1963).
6. U. Schröppler and K. Rühlmann, Chem. Ber., 97, 1383 (1964) and earlier papers cited therein.
7. R. B. Woodward and R. Hoffmann, J. Am. Chem. Soc., 87, 395 (1965).
8. G. J. Fonken, results reported at Photochemistry Symposium, Houston, Texas, February 17-18 (1967).

TABLE I
 Acyloin Condensation of Some 1,2-Dicarboxylates^{a, b}

Starting Ester	Product	Yield, %
 <u>1</u>	 <u>2</u>	89 ^c
 <u>3</u>	 <u>4</u>	80
 <u>5</u>	 <u>6</u>	94
 <u>7</u>	 <u>8</u>	(86)
	 <u>9</u>	
 <u>10</u>	 <u>11</u>	88
 <u>12</u>	 <u>13</u>	90
 <u>14</u>	 <u>15</u>	76

Notes to Table I

- a) Unless otherwise indicated, the reactions were conducted under nitrogen in refluxing toluene containing 0.44 g atom of sodium dispersion (freshly prepared) to which was added 0.1 mole of the diester in a solution of toluene containing 0.45-0.5 mole of chlorotrimethylsilane. Addition of the ester required 1-3 hrs and reflux was continued for 8-16 hrs.
- b) Satisfactory analytical and spectral data have been obtained for the new compounds.
- c) Compound 1 has also been successfully cyclized in comparable yield using potassium metal in refluxing benzene and with an excess of sodium-potassium alloy at room temperature.
- d) The cyclooctatriene is produced in refluxing toluene by rearrangement of the first formed bicyclooctane (see text).