Stereochemistry of the Ring-opening of an Activated Vinylcyclopropane

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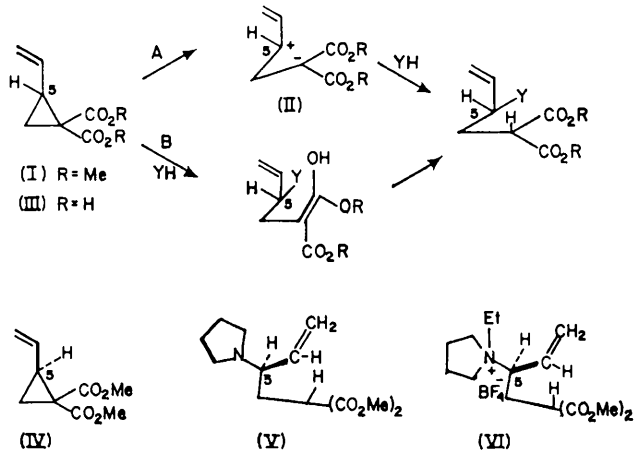
Summary Optically active dimethyl 2-vinylcyclopropane-1,1-dicarboxylate reacts with pyrolidine with clean inversion of configuration at C(5); its reaction with enamines appears to involve prior cleavage of the C(3)–C(5) bond.

THE predominant pathway for the reactions of nucleophiles with (I) involves ring opening *via* 1,5-attack,[1] except in its reaction with enamines.[2] In terms of a nucleophilic displacement, the preponderance of the 1,5-pathway may be related to the general prevalence of S_N2 relative to $S_N'2$ displacement;[3] alternatively, special factors may be operative.

One possibility involves unimolecular ionization[4] to give the delocalized dipolar specie (II), which might be attacked by the Y-H nucleophile so that the two charge-cancelling components† are delivered simultaneously to the charged ends of the dipole (path A). Alternatively, the scission of the cyclopropane bond may be concerted (path B). Path A would lead to racemization at carbon C(5), and path B retention of configuration at this centre. If the process corresponds to S_N2 displacement, inversion about C(5) would, of course, be expected.

Diacid (III) was resolved *via* its monobrucine salt and esterified with diazomethane to give (IV), $[\alpha]_D$ (CCl_4) +55·2°. Reaction of (IV) (arbitrary configuration) with pyrrolidine at 100—110° to one-third completion gave (V), $[\alpha]_D$ (CCl_4) +4·4°. Recovered (IV) had lost none of its optical activity. Treatment of (V) with triethyloxonium fluoroborate gave (VI), which underwent smooth intramolecular alkylation when stirred with sodium hydride in dimethoxyethane to give (IV) $[\alpha]_D$ (CCl_4) +55·3°. Since the conversion (VI) → (IV) can be assumed to involve inversion about C(5), the transformation (IV) → (V) must also involve inversion about the same carbon atom. Thus 1,5-attack corresponds to a traditional nucleophilic displacement.

Compound (IV) was racemized by thermolysis in inert solvents. Thus, at 140° (in xylene) $t_{\frac{1}{2}}$ (rac.) = 75 h, while at 180° (in *p*-cymene) $t_{\frac{1}{2}}$ (rac.) = 3·5 h. The simplest mechanism for racemization involves cleavage of the 3–5 bond,[4] rotation about the 3–4 bond, and recombination; an alternative mechanism, which cannot be ruled out, involves reversible formation of a 2,5-dihydro-oxepin.[5,6] However, in contrast to the work in ref. 6, we were unable to detect



any oxepins in the thermolyses of (IV). The previously reported[7] rearrangement of (I) to diethyl cyclopent-4-ene-1,1-dicarboxylate begins to occur at 250°. After 18 h in *p*-cymene the ratio of vinylcyclopropane to cyclopentene is 15:85 [*cf.* $t_{\frac{1}{2}}$ (rac.) = 3·5 h at 180°]. That isomerization to a cyclopentene is not a necessary consequence of ring cleavage of a vinylcyclopropane has already been demonstrated.[8]

The conditions leading to the 1,7-addition of enamines to compound (I) (180°; 65 h; *p*-cymene), in conjunction with the racemization results, are consistent with the proposition that the enamine process involves trapping of the dipolar species (II) by attack of the nucleophile at the terminus of its allylic portion.† The close parallel between the efficiency of the enamine process and $t_{\frac{1}{2}}$ (rac.) for (IV) agrees with this interpretation, which also accounts for the anomalous 1,7-attack.

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† Enamine addition[2] would correspond to a nucleophile of the type Y: rather than Y–H and would not be susceptible to this effect.

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