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A DICHOTOMY IN THE ELECTROCYCLIC RING CLOSURE OF ENOLS AND ENOLATES

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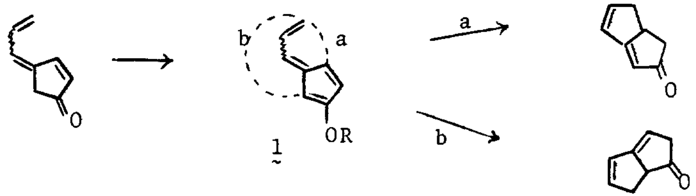
The occurrence of a series of natural products with interesting biological properties based upon the fusion of cyclopentane rings has led us to embark upon an examination of synthetic approaches to them.[2] The success of the electrocyclic ring closure of alkylidene cyclopentadienes[3] suggested that the enol or enolate of an alkylidene cyclopentenone would provide ready access to



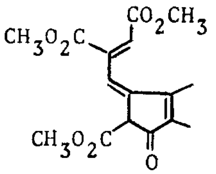
1

R=H or Metal

Eq. 1

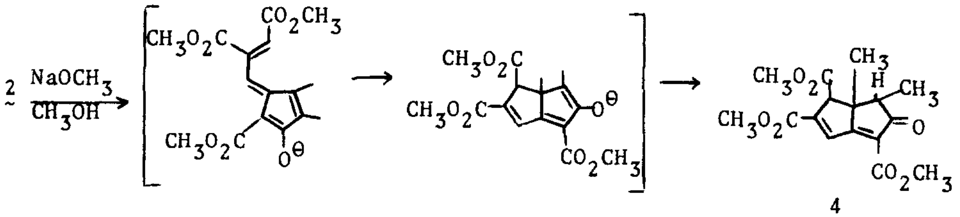
the desired ring systems (eq. 1). We wish to report a novel dichotomy in the behavior of the enol or enolate in a derivative of 1.

Compound 2, available as part of a program in terpene synthesis, is an excellent candidate to explore such cyclizations.[4] Treatment of 2 with



2

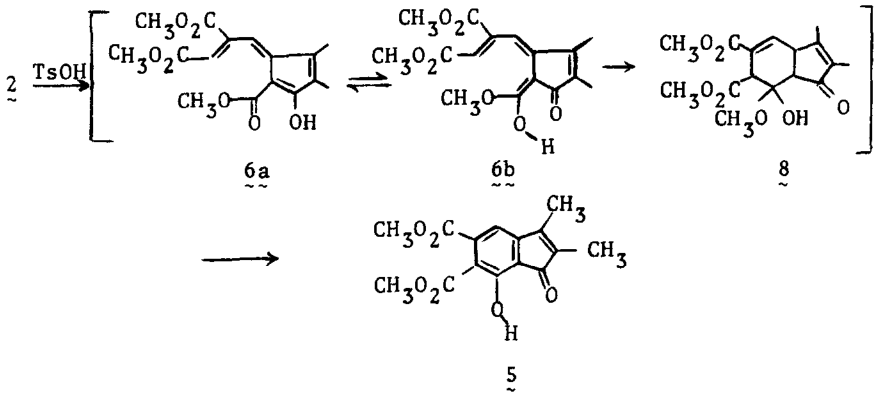
methanolic sodium methoxide generated a deep black-red solution which lightened in color upon warming to 60° for 30 min. Work-up gave an oil which crystallized in 50% yield from ether-pentane at -78°, but melted upon warming to room temperature. Its mass spectrum established the formula as $C_{16}H_{18}O_7$ (found: 322.1049). Its ir showed a broad carbonyl stretching vibration at 1725 cm^{-1} and the double bond stretching vibration at 1640 cm^{-1}. The uv indicated an extensive chromophore: nm (ε) 445 (2400) and 300 (9600). The nmr spectrum provides the additional information to establish the bicyclooctane 4 as the structure. Three distinct methyl esters had absorptions at δ 3.67, 3.73, and 3.75. A single vinyl proton, δ 7.56, with only allylic coupling to a methine hydrogen (d, J = 2 Hz), a methyl (δ 0.96) on a quaternary carbon and one (δ 1.13, J = 7 Hz) on a secondary carbon alpha to a carbonyl group (methine at δ 2.63, q, J = 7 Hz) complete its characterization. The formation of 4 can be readily accommodated by the 8π electron electrocyclic reaction (see eq. 2) and the regioselectivity is probably determined by the stereochemistry of the exocyclic double bond of 2.



4

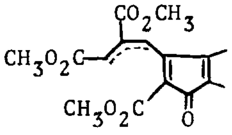
Eq. 2

On the other hand, treatment of 2 with *p*-toluenesulfonic acid monohydrate in toluene at reflux gave a completely different yellow product (~60%). The mass spectrum established the formula as $C_{15}H_{14}O_6$ (found: 290.0816). The infrared spectrum showed the presence of hydroxyl (3400 cm^{-1}), conjugated ester (1725 cm^{-1}), ketone (1687 cm^{-1}) and double bond (1619 cm^{-1}).[5] The nmr spectrum showed, in addition to the broad hydroxyl absorption centered at δ 9.3, an aromatic singlet for 1 H (δ 6.88). two methyl esters (δ 3.89 and 3.91), and two vinylic methyl groups (δ 1.84 and 2.12). These data clearly indicate the indenone structure 5. The uv data [nm (ε) 450 sh (1310), 370 (2930), and

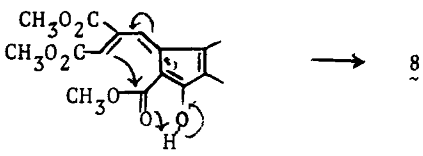


239 (25690)] confirms this interpretation.[5]

The formation of 5 can be understood by considering the possible enols. Cyclization onto the substituent on C-2 rather than C-4 of 2 requires an acid catalyzed isomerization of the alkylidene double bond. The cyclopentadienone 7 would be a reasonable intermediate in such an isomerization. The



7



9

most intriguing aspect is the competition between the 6π electron process in the less favorable tautomer 6b versus the 8π electron process in the more favorable tautomer 6a. An alternative, equally plausible rationale as depicted in 9, avoids invoking the unfavorable equilibrium of 6a $\rightleftarrows$ 6b. In either case, the exclusive formation of 5 indicates a considerable preference for a Hückel compared to a Möbius transition state.[6] These results demonstrate not only the utility of the base catalyzed electrocyclic reaction for the formation of bicyclooctadienones, but also provides a new route to indenones.

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