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REACTIONS OF DICARBONYL COMPOUNDS WITH DIMETHYL β-KETOGLUTARATE V.[1] SIMPLE SYNTHESIS OF TRICYCLO[6.3.0.0^{1,5}]UNDECANE-3,7,9-TRIONE, A NOVEL CYCLOPENTANOID COMPOUND

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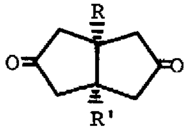
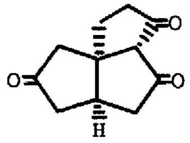
Polycyclic ring systems composed of cyclopentane units have been the object of much recent interest; triquinacene,[3] peristylane,[4] the still hypothetical dodecahedrane, and the compounds described by Paquette et al.[5] may serve as examples of such cyclopentanoid compounds. In earlier papers of this series, we have shown that the reaction of dimethyl β-ketoglutarate with aliphatic and alicyclic α-dicarbonyl compounds is a convenient source of β-ketoesters derived from such ring systems; acid-catalyzed hydrolysis and decarboxylation gives the parent cyclopentanoid ketones. Aliphatic α-dicarbonyl compounds yield cis-bicyclo[3.3.0]octane-3,7-diones (**1**),[6] while alicyclic 1,2-diones produce derivatives of the [n.3.3] propellane series (**2**).[6,7] In the case of glyoxal, two stereoisomeric tetracyclic cyclopentanoid compounds are formed in addition to **1**.[8a,b]

We now wish to describe the utilization of this reaction with a suitable aliphatic α-ketoaldehyde, **3**, for the synthesis of tricyclo[6.3.0.0^{1,5}]undecane-3,7,9-trione (**4**); interestingly, a compound derived from this ring system has been obtained very recently[9] during formolysis of certain substances with the protoilludan skeleton.

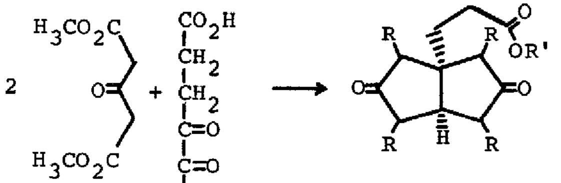


1, R, R' = H or alkyl

2, R, R' = $-(CH_2)_n-$



4



3

5, R = CO_2CH_3, R' = H

6, R = CO_2CH_3, R' = CH_3

7, R = R' = H

8, R = H, R' = CH_3

The α-ketoaldehyde 3 (4,5-dioxopentanoic acid) was prepared by ozonolysis of 5-benzylidenelevulinic acid, essentially following the method of Zaheer *et al.*[10] The resulting oil was then stirred with two moles of dimethyl β-ketoglutarate in aqueous sodium bicarbonate for 72 hours at room temperature. Acidification of the solution to pH = 1, extraction with chloroform, followed by evaporation of the solvent and crystallization of the residue from methanol gave tetramethyl 1,3'-propanoic acid bicyclo[3.3.0]octane-3,7-dione-2,4,6,8-tetracarboxylate (5)[11] in 80% yield (mp 154-156°); methyl ester 6 (mp 109-111°). Refluxing 5 in a mixture of acetic and hydrochloric acid provided the monoacid 7 (mp 101-102°, 70% yield), methyl ester 8 (mp 96-98°). Repeated attempts to cyclize 8 to the desired triketone 4 using basic catalysts proved uniformly unsuccessful; *e.g.*, NaOMe in MeOH gave dimeric aldolization products and NaOMe in DMSO, or sodium hydride in toluene, similarly failed to yield any of the triketone. Attempted base catalyzed cyclizations of 6 to the tetracarbomethoxy derivative of 4 were likewise unsuccessful.

However, refluxing the monoacid 7 in benzene/dioxane in the presence of a catalytic amount of naphthalene-1-sulfonic acid[12] gave a 60% yield of a compound, shown by mass spectrometry to have a molecular weight of 192, which was assigned as the tricyclic triketone $C_{11}H_{12}O_3$ (4);[13] mp 142-143° (from methanol). Ir and ^{1}Hmr also supported this structure. Further proof for this assignment was obtained by examination of the ^{13}Cmr spectra of the monoacid 7 and the triketone

4. In the spectrum (see Table 1) of 7 the signal for the carboxylic acid carbon appears at 177.7 ppm; however, on conversion of this compound to 4, this resonance disappeared and a new signal was found at 206.5 ppm, in complete agreement with the formation of the third cyclopentanone ring; the other signals in the ^{13}Cmr spectrum of 4 were not exceptional and fit well for the assigned structure.

No direct evidence on the stereochemistry of the ring systems in compounds 4-8 is available; we formulate them as the *cis*-compounds since it is known[14] that *cis*-bicyclo[3.3.0]octane is the thermodynamically more stable isomer and since 1 has been shown[15] to be the *cis*-compound. Furthermore, X-ray crystallographic analysis on the *endo* stereoisomer of the tetracyclic triketone obtained from dimethyl β-ketoglutarate and glyoxal[8b] indicated *cis*-stereochemistry at all ring junctions. The tricyclo[6.3.0.0^{1,5}]undecane system present in the pentacyclic sesterterpene, retigeranic acid, has also been shown to have this *cis*-stereochemistry.[16]

TABLE 1. ^{13}Cmr spectrum of the triketone 4 and suitable model compounds[a]

Bicyclo[3.3.0]octane-3,7-dione	217.77, 43.65, 36.50
7	216.80, 177.73, 47.85, 47.07, 43.74, 41.80, 33.40, 30.18
4	215.5, 206.53, 68.45, 53.21, 48.53, 44.72, 43.74, 39.93, 38.66, 32.52

[a] These spectra were recorded on a Varian CFT-20 nmr in $CHCl_3$ (internal standard $(CH_3)_4Si$).

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